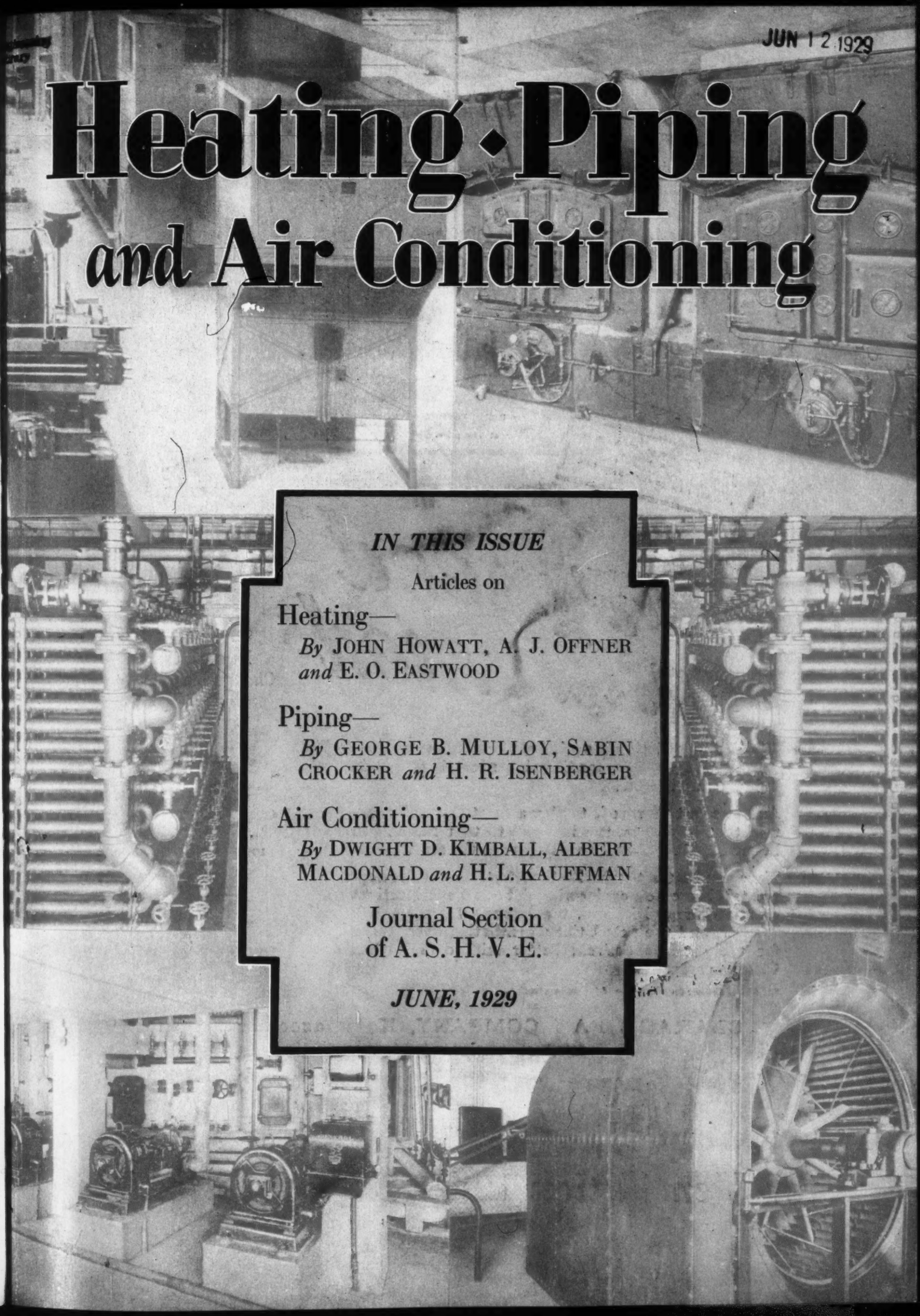
JUN 12 1929

Heating · Piping and Air Conditioning



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Articles on

Heating—

By JOHN HOWATT, A. J. OFFNER *and* E. O. EASTWOOD

Piping—

By GEORGE B. MULLOY, SABIN CROCKER *and* H. R. ISENBERGER

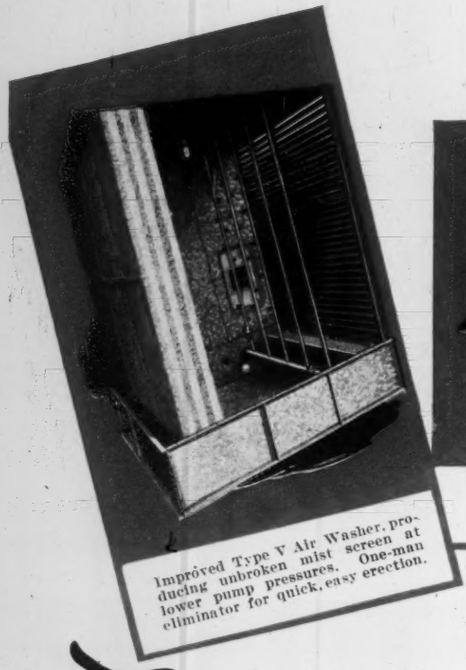
Air Conditioning—

By DWIGHT D. KIMBALL, ALBERT MACDONALD *and* H. L. KAUFFMAN

Journal Section
of A. S. H. V. E.

JUNE, 1929

Heating · Piping
and Air Conditioning



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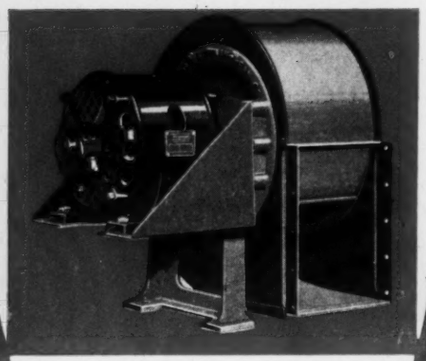

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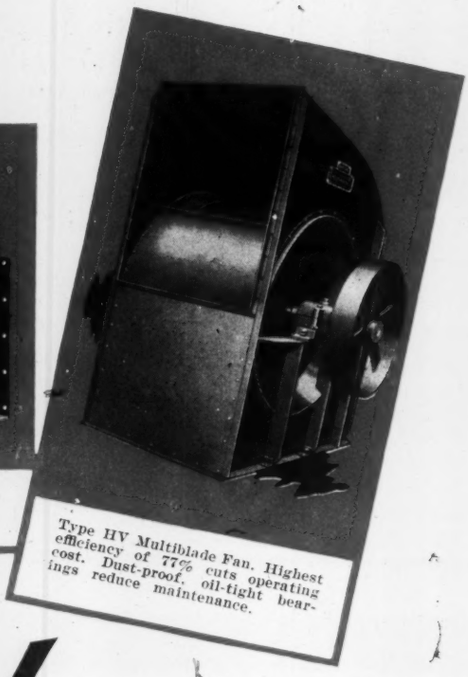

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WHAT OUR READERS SAID ABOUT THE FIRST ISSUE

We like a criticism that has been made of our May issue, Volume 1, Number 1. We like it for two reasons. It is a compliment. And it is a challenge which we are glad to accept.

This criticism is that our first issue set a standard that will be difficult to maintain. It suggests that we wanted to make an impression, so we shot our "Big Bertha" and can hardly have anything but light artillery left. And it ends up, with a tinge of doubt to the statement, that if we can keep it up we have a winner.

That is, of course, a compliment to the first issue. It is not the only one, incidentally. Hundreds of letters have come to us from our readers commending our contents, our appearance and our plans. Many contained valuable suggestions for improvement, which we appreciated and will endeavor to follow. Practically all of them said to keep it up and, as we say, many seemed to wonder if we can. And that is the challenge.

However, with us it is not a question of keeping it up. It is a question of making each issue better. That is an obligation we assumed when we decided to meet the need that existed for technical and practical information on heating, piping and air conditioning. The first issue, as we said, was only the first step in a carefully reasoned plan of editorial service. This second issue is only the second step. And there will be many more steps. In the nature of steps, each one should be a forward one—a better one than the previous.

In this issue we have tried to make it so. We introduce more of our consulting and contributing editors, each, just as in the first issue, well qualified by experience and knowledge to handle the subject he covers.

BUDGETING TO CHECK POWER WASTE

George B. Mulloy writes from an experience of twenty years with one of the world's largest packing plants, at which he was chief combustion engineer and assistant superintendent of motive power when, a year ago, he established a department of industrial engineering with Consoer, Older & Quinlan, consulting engineers of Chicago. Such a background and present connection make him thoroughly capable of giving the engineer in industrial plants an efficient method for checking waste and for operating economically, as he does in his article, "Generating and Distributing Motive Power."

NATIONAL STANDARDS FOR PIPING

Sabin Crocker, engineer with Detroit Edison Co., is one of the country's authorities on piping. He is active on practically every committee in the engineering field which has to do with piping, being a member of the A. S. A. Sectional Committee on Pipe, Flanges and Fittings; the A. S. A. Sectional Committee on Code for Pressure Piping; the A. S. A. Sectional Committee on Wrought Iron and Wrought Steel Pipe and Tubing; and A. S. T. M. Committee A1 and A3. "National Standardization of Piping" is his article. It is a subject which no one could handle better.

IN THE FIELD OF HUMAN COMFORT

Alfred J. Offner, mechanical engineer of the consulting firm of Offner & McKnight, New York City, has specialized for years in the design of heating and ventilating systems for hospitals, churches, hotels, banks, office buildings, apartments, etc. With many large jobs on his list, he can speak with authority on the factors to consider in heating and ventilating hospitals, which is the nature of his article in this issue.

Dwight D. Kimball, our consulting editor on air conditioning, has been engaged for the last thirty-two years in consulting engineering work. He is in such work now in New York City. He is one of the leading engineers in the country on air conditioning and, in this issue, deals with air conditioning in its relation to human comfort and health.

How to Collect Dust

Albert E. Macdonald is a professor of civil engineering at the University of Manitoba, Winnipeg, Canada. His work brought him in close touch with the mechanical equipment and structural details of the world's largest grain elevator, and he describes the dust collection system in this elevator.

Getting Rid of Fumes

H. L. Kauffman is a consulting engineer of Denver, Colorado. His articles on the elimination of obnoxious fumes in various manufacturing processes will hit upon problems being faced by engineers in many industrial plants.

Power—Produce or Buy?

E. O. Eastwood is head of the department of mechanical engineering at the University of Washington, and does general consulting work in Seattle. "Heat—With or Without Power" is a question for many universities, industrial plants and institutions to decide for themselves. The tests conducted by Professor Eastwood will be of interest to all.

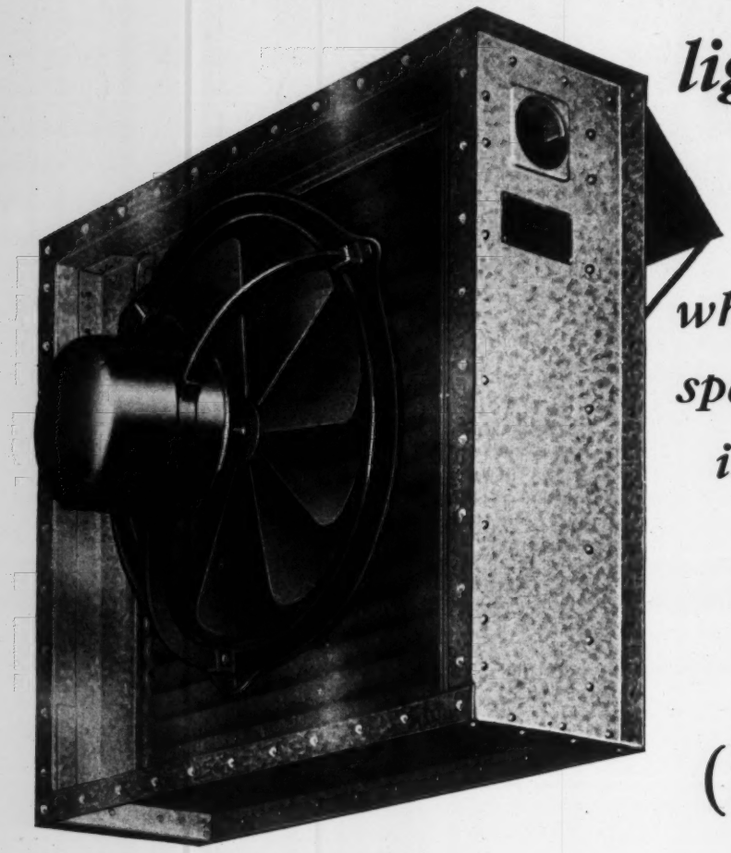
Seeing Through Materials

Herbert R. Isenberg is an expert in the application of X-ray to material testing. It should be of great interest and of practical value to the engineer to learn of the use of the X-ray for inspecting piping materials, and Mr. Isenberg, in his article, explains the method and gives interesting examples of fittings that were put under the X-ray test.

Kinks in Piping

W. H. Wilson is with us again this issue. Foreman of pipe fitters in a large industrial plant, his articles are always practical. Many of our readers found his "kinks" in last month's issue usable. They can use also his suggestions on steam mains.

—and the modern



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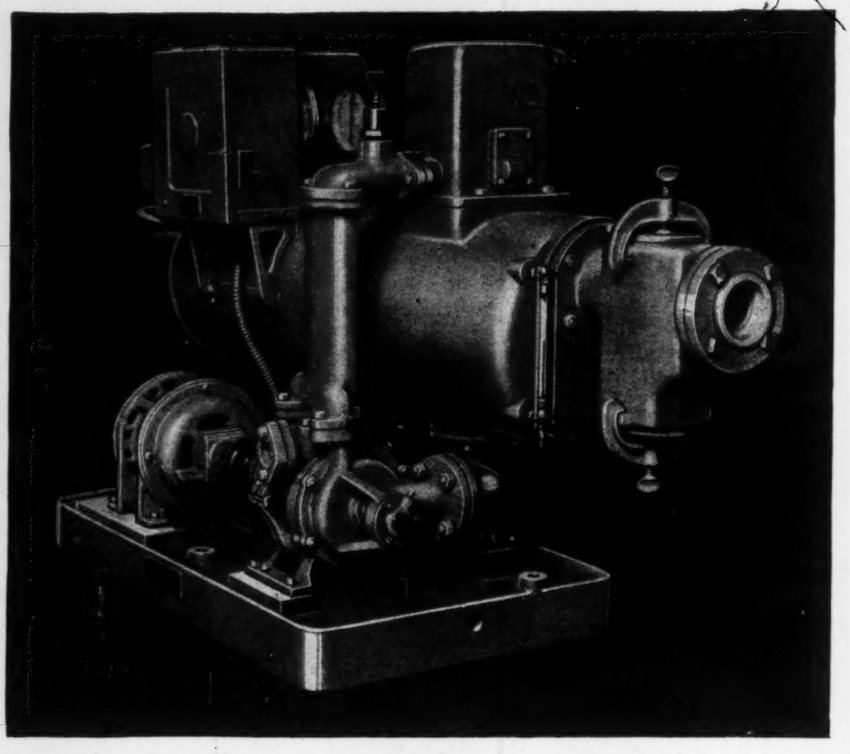

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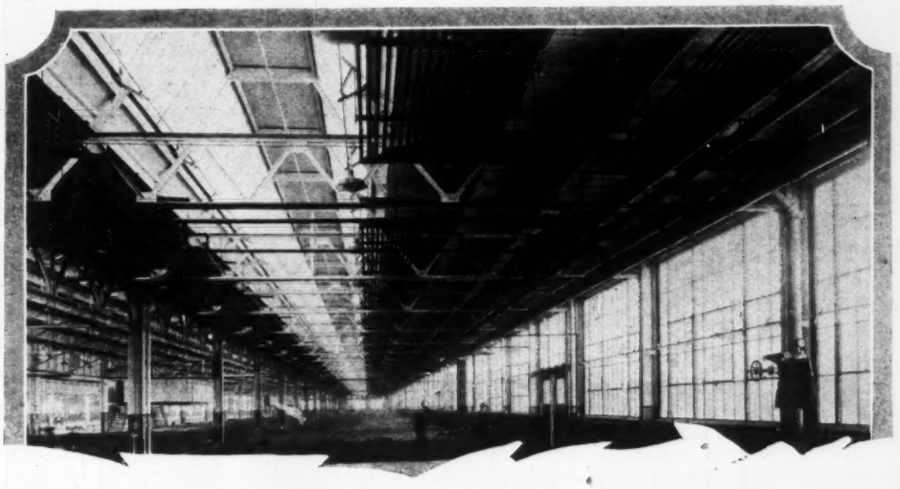


Generating and Distributing Motive Power

Budgeting Load Requirements in an Industrial Plant Stopped Losses

By George B. Mulloy

NATIONALLY we have a reputation of being very extravagant in the utilization of the natural resources, such as fuel, mineral deposits, timber, etc. All these enter into the cost of manufacture and, with the ever upward trend in the price of labor, if not because of scarcity of these natural resources, the executive is beginning to give his motive power department some careful consideration.

The basic beginning of all economy in most industrial plants, regarding the generation of power, is the coal pile or equivalent, such as oil or gas. Whatever the grade used, it contains the 100 per cent undeveloped energy and it is at this point that the largest percentage of improvement in economy can usually be made.

In many cases great efforts have been made to obtain the desired economy by the installation of a highly efficient type of prime mover, arranging for the proper load and power factor by selecting the proper kind of motors. Also, the value of exhaust steam and its application is quite generally understood. All this is a step toward ultimate economy. But from experience the writer has found that very astonishing returns can be obtained by the proper attention to the boiler room.

In a certain industry where the total expense of motive power operation amounted to $11,000,000 per year, the annual fuel bill amounted to nearly $6,000,000. Much attention was given to the entire account and the various items entering into the total expense were examined periodically with the view of keeping them in line. But by concentrating on the one largest individual item—that is, fuel—it was possible to decrease the amount consumed per 100 weight of goods manufac-

tured by approximately 12½ per cent, and in money this amounted to more than $500,000 per year.

This very appreciable saving was not made by an extensive program of reconstruction in boiler plant equipment, such as boilers, furnaces, arches, stokers, etc., nor by radical changes in the personnel.

Set an Overall Operating Standard

The first thing necessary was a complete study of the situation and conditions as they existed, the method of operation of various grades of fuel used, variations in plant loads and amount of supervision given the subject as a whole.

The next step was to determine accurately as nearly as possible just what was being accomplished in the way of daily evaporation and to correct this if found to be below standard.

Checking of the controllable losses was also given very close attention and a tentative heat balance was worked out for each plant involved. Knowing wherein existed the greatest and most important controllable losses, the thing obviously to do then was to prevent them from exceeding a set standard.

In the general plan of curtailing these losses it was found necessary to resort to a form of records that would quickly show up any deviation from an overall standard set for each plant, which standard took into consideration its own particular equipment and corresponding requirements.

To obtain the data required, it was found necessary to equip the plants with the required recording apparatus to indicate continuously what losses were getting out of line. In many cases the entire equipment so installed at each plant paid for itself in a period of three months.

By keeping this set of daily records so designed as to show at a glance the necessary operating data, it did not take long to determine each plant's characteristic overall efficiency and keep each plant operating at this efficiency.

Proper Selection of Coal

One of the first steps in reducing the cost of producing steam in most boiler plants is the proper selection of coal for the equipment at hand, load to be developed and the amount of draft available. This step is one of the most important and has much bearing on the ultimate success of the effort. All coals, as prepared for the calorimeter tests, are pulverized to an extremely fine degree and, in the process of testing in the laboratory, a supporter of combustion is used to obtain quick and complete combustion.

TABLE 1—UPTAKE TEMPERATURES AT DIFFERENT RATINGS

	Class 1 (3 Banks x 6 Tubes, 18 Tubes Deep) Flue-Gas		Class 2 (3 Banks x 5 Tubes, 15 Tubes Deep) Flue-Gas		Class 3 (3 Banks x 4 Tubes, 12 Tubes Deep) Flue-Gas	
Rating Per Cent	Temp. Deg. F	Efficiency Per Cent	Temp. Deg. F	Efficiency Per Cent	Temp. Deg. F	Efficiency Per Cent
100	445	76-77	475	75-76	505	73-74
150	530	75	560	74	590	73
175	575	73	605	72	635	71
200	620	72.5	650	71.5	680	70
225	680	70	710	79	735	68
250	730	68	760	68	790	67

Note:—Superheaters give about 15 deg. lower flue-gas temp. These data are based on burning coal containing 11,500 to 12,000 B.t.u.

TABLE 2—HEAT LOSSES IN DRY CHIMNEY GASES CORRESPONDING TO CO_2 CONTENT AND FLUE GAS TEMPERATURE (Bituminous Coal)

CO_2 in Flue Gas,	Temperature of Flue Gases, Deg. F.						
Per Cent Volume	400	450	500	550	600	650	700
15	7.8	9.0	10.1	11.3	12.5	13.7	15
14	8.3	9.6	10.8	12.1	13.4	14.6	15.8
13	8.8	10.2	11.6	13	14.4	15.6	17
12	9.5	11	12.5	14	15.5	16.9	18.4
11	10.3	11.9	13.5	15.1	16.7	18.3	19.9
10	11.3	13.1	14.9	16.6	18.4	20.1	21.8
9	12.5	14.5	16.4	18.4	20.2	22.1	24.1
8	14.1	16.3	18.5	20.6	22.7	24.8	27
7	16.1	18.5	20.9	23.3	25.8	28.3	30.8
6	18.5	21.4	24.4	27.3	30.2	33.2	36.1
5	22.1	25.5	28.9	32.3	35.7	39.1	42.5

The results thus obtained are to be used in making a heat balance and are only indicative of what may be expected from the coal on a practical burning test. It is obvious that coal from a given seam and from the same mine will handle differently on the same grate, depending upon the percentage of "fines." This is one of the reasons that there is considerable doubt at times on the part of the purchaser whether he is getting the grade of coal for which he is paying.

He may be buying coal from one dealer under a trade name and size that fits his conditions, and for some reason changes his dealer but insists on the same kind of fuel. When it is received, he is much surprised to find he does not get the same results and wonders why. Too great a percentage of "fines" causes either excessive sifting through the grates, or blankets off the air seeking entrance into the furnace through the fuel bed, all of which has a detrimental effect on the capacity and overall efficiency obtained.

It is for this reason that any plant burning 10 tons of coal per day can well afford to consider the use of its own coal crusher, and the crusher should be of such a type that it can be regulated so the owner can prepare the size of coal best suited for his conditions. Being thus equipped, he is then more or less free to experiment with different grades of coal and has a wider range of selection which in turn allows him to take full advantage of market conditions.

Evaporation Basis of Comparison

After experimenting with various grades of coal and finding by actual burning tests the amount of evaporation obtained per one pound of fuel as fired, the results can then be calculated to commercial pounds of steam by using the correct factor of evaporation. Using this factor puts the evaporative power of the coals on a practical basis of comparison which is the object in view in making the burning tests. When the object of the test is of a more scientific investigation involving a complete heat balance, then it is usual to express the evaporative results in the terms of combustible. In either case, the factor of evaporation is used and the curve shown in Fig. 1 will be useful in determining this factor for ranges in steam pressure from 120 to 170 pounds gauge and a range in quality of 2 per cent moist to 70 degree superheat.

After a series of burning tests made on various coals,

one or more grades will be found to be generally satisfactory regarding their free burning qualities, and these coals should be selected as standard from which all other coals should be compared in value for this particular plant.

In order that all the coals tested and under consideration should be given a fair show to demonstrate their burning qualities, care should be taken to test them out on the same boiler and stoker. The boiler should be in the same relative condition regarding cleanliness of the tube surface externally and internally. The baffling in the boilers should be tight as well as the setting.

Careful observations regarding the CO_2 and uptake temperatures should be made during the tests, and to get reliable results these readings should be taken from recording types of instruments. Other items for careful consideration are, of course, the method of weighing the coal, water and ash as well as selecting a truly representative sample of coal burned and the resulting ash obtained.

Knowing where, when and how the steam, water, compressed air, refrigeration, etc., are used in an industrial plant, an overall standard of operating requirements can be established and against it the daily plant operation can be checked for wasteful distribution and utilization. The result will be economy in fuel and economy in capital investment for equipment.

The actual burning tests are of much more practical value to the plant owner than the chemical analysis which is often quoted in the process of selling the respective coals to the owner, for he is seeking results more than an education in the chemistry of the problem.

In the larger plants where the item of fuel is large, it is found to be a paying proposition to employ men having some technical training regarding the art of combustion. Many firms are inducing the men to take a course of study on this subject and are either defraying the entire expense or are helping out partially.

Also, as there is now on the market a variety of control apparatus of known merit, these plants are spending considerable money to equip their boilers with instruments which will greatly aid in the process of educating the firing crew and allow them to make the necessary changes in operation as the situation demands.

Flue Gas Temperatures

In further reference to flue gas temperatures, there is a certain temperature that should exist for a given load with every boiler and setting.

It is well to take as a standard temperature that which is guaranteed by the manufacturer of the boiler, as he is sure to state what this temperature should be at different ratings under a given set of conditions regarding steam pressure, quality of coal, type of baffling and given amount of CO_2. Knowing what these temperatures should be for a clean boiler with tight furnace settings, the boiler room operator should see to it that this range of temperatures of escaping gases should be adhered to. Table 1 shows what temperatures to expect with the bent water tube type of boiler. Any great variation from these temperatures indicates that the boiler should come off the line for inspection and cleaning. Similar data can be prepared for other types of boilers.

Fig. 2 shows a convenient form for determining the number of boilers that should be carried on the line to meet the load demands under a given condition of rating. Every plant owner knows from his daily operations which is the proper load to carry to obtain the best overall efficiency.

Table 2 shows the significance of holding the excess air entering the furnace down to a minimum, and this is indicated by the amount of CO_2 maintained in the uptake. Samples of this should be taken regularly at short intervals of time, preferably from a recording instrument, the suction of which is connected to the uptake immediately below the damper and extending far enough across the flue to obtain an average sample. A table of this kind can be worked out for every grade of fuel and should be consulted continuously by the operator.

It is quickly noted that as the CO_2 rises in the first column, the heat losses due to excess air decrease, but in raising the CO_2 the temperature is reduced owing to the better heat absorption, which is due to the smaller volume and consequent reduced velocity of gases.

For example, increasing the CO_2 from 10 per cent at a flue gas temperature of 600 degrees F. to 15 per cent shows a reduction in heat losses of 18.4—12.5 or 32.0 per cent of this particular loss. In the actual process, however, the flue gas temperature may drop to 550 degrees F. or lower, depending upon the cleanliness of the heating surface, so that the reduction would be 18.4—11.3 or 38.6 per cent of the excess air losses.

Distribution and Utilization

The next step in keeping the cost of manufacture down to a minimum is to know where and how the energy is being used throughout the plant. It accomplishes very little to generate it economically in the boiler room and then to dissipate the effort by wasteful distribution and utilization.

In all cases where various forms of energy are used, such as electrical power, steam, compressed air, water and refrigeration, there exists in most plants a cycle of operation for the use of these forms of energy, and this cycle is being continuously repeated every day.

Cycle of operation is usually the term applied to the daily use of all forms of energy generated. In most plants the cycle is the same day after day and the processes demanding the use of energy occur regularly at approximately the same period of the day throughout the year.

In order to effect economy, then, it becomes necessary that this cycle be thoroughly understood by the plant owner, the superintendent in charge of production, as well as the engineer.

In a well operated plant, the greatest total demand for energy output usually occurs simultaneously with output of manufactured product. If the demand for maximum power output is not in phase with maximum requirements of production, then things are out of balance and the operation is not conducive to the best economy.

Know the Load Conditions

Knowing the cycle of operations well, allows one to anticipate in advance the load curve fluctuation and to prepare for the peaks or depressions which occur from hour to hour throughout the day. By being forewarned as to these events, it is then possible to put on or take off the line a given number of boilers, engines, motors, or various machines, so the balance of the equipment is correct in number and capacity to carry the load at the best efficiency.

An irregular and intermittent load is usually a very difficult one to meet satisfactorily, as far as economy is concerned, because of the sudden fluctuations and short intervals of time usually existing between these variations of load.

Before a heat balance or power distribution, which is only an audit, can be made, showing where and how much energy is being used for the various steps in a manufacturing process, it is necessary to make individual tests on each of the machines or steps in the processes entering into the complete or final product. These tests involve the measurement of the steam, water, electricity, compressed air, and often the amount of refrigeration used. The method for obtaining these data usually consists of installing the proper type of meters for the particular form of energy being measured.

After obtaining the data on the amount of the kind of energy in question, giving consideration to the capacity being developed at the time, the results are expressed in terms of units of energy per unit of product being manufactured; for example, so many boiler horse power, kilowatts or engine horse power per hundredweight, per ton, per square foot, or some other convenient unit of manufactured goods.

A table then can be worked for each step in the process of manufacture, showing how much steam, water, compressed air, refrigeration or electrical power is used in terms of one unit of finished or manufactured goods. In this way, it is possible to obtain the necessary information without making a complete installation of metering equipment.

Easy to Detect any Excess

Having the amount of energy required for each step per unit of product handled, then it is possible to detect the excessive use of energy for any one day's production of manufactured goods. In many lines of industry, it will be found that running the factory on any but full capacity is very uneconomical unless provisions have been made to do so by installing the equipment with this object in mind.

In trying to get out more production with a given equipment in a working day's time of either eight or ten hours, it is often found more economical to increase the number of shifts from one, to two or three and stay within the normal rating of the machinery involved. This method of operation tends to smooth out the load curve, produce better economy by allowing the equipment to operate at normal rating and in many cases forego the necessity of further investment of capital in additional machinery to obtain production.

Recovering Waste Saved Boiler Purchase

In a recent case, the writer had occasion to demonstrate to a plant owner the necessity and value of abso-

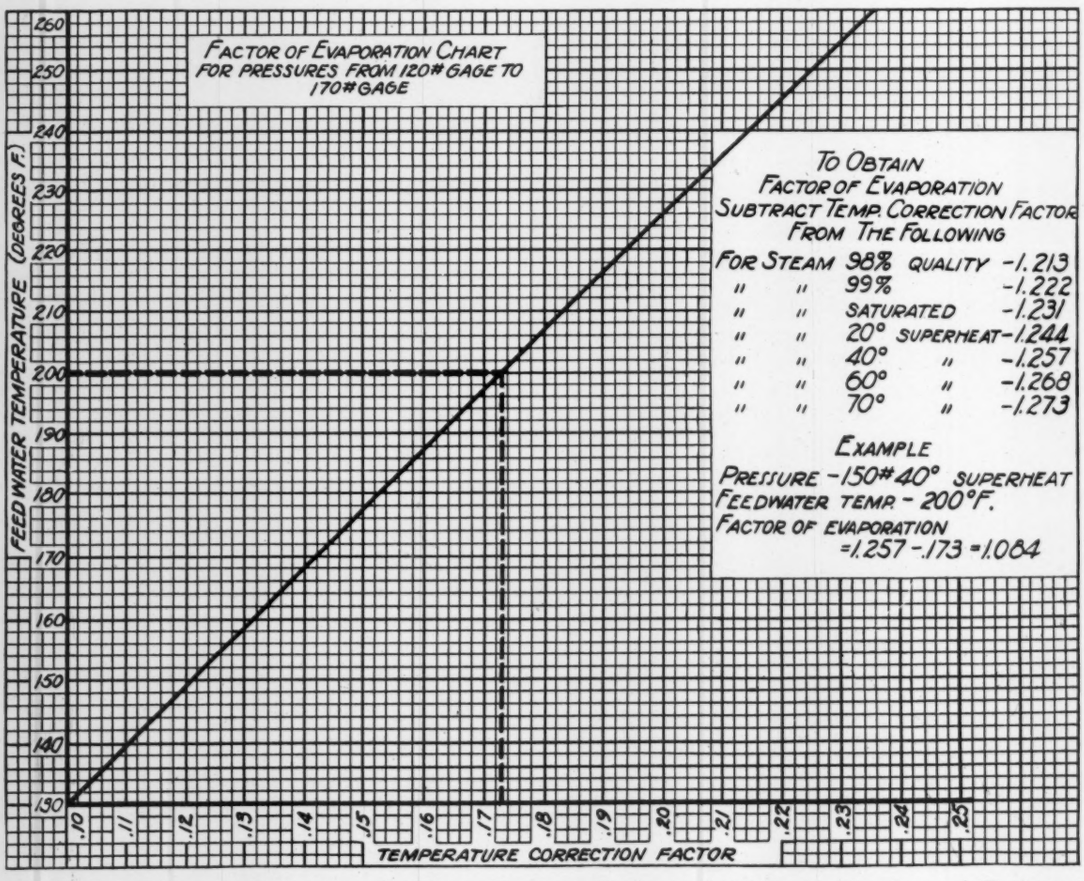


FIG. 1.—THE FACTOR OF EVAPORATION IS USED TO PUT THE EVAPORATIVE POWER OF COALS ON A PRACTICAL BASIS OF COMPARISON.

lutely knowing the exact cycle or distribution of the energy generated daily. The reason for the investigation was to decide whether or not more boiler capacity was needed. The plant in question had three boiler units having an aggregate total capacity of 1,400 B.H.P. Because of the nature of the business, one unit could be used only on one line of production, while the other two units were kept in constant use generating a lower pressure steam. Because of the fact that the latter units were on the line 24 hours a day, every day in the week, it was not possible to keep them in the proper state of repair and consideration was being given to the advisability of installing more capacity.

The services of a consulting engineer were obtained and a complete distribution of the plant load was made.

Tests were made on the various steps of the manufacturing process and the results plotted. Much to the surprise of every one concerned, the distribution showed up entirely different than was anticipated regarding the amount of loss in the form of heat that was escaping from the plant.

When this loss was figured back into pounds of commercial steam and added up with the steam consumption determined by tests for the other steps, running the auxiliaries, etc., the sum checked up with the total steam generated.

The result of the distribution was to give more consideration to the possibility of recovering the wasted heat, with less expenditure of capital for heat recovery apparatus than would be required for an additional boiler. The distribution showed that by knowing where the energy was being used and how much was being consumed it was possible to economize at various points in the use of power. This meant that it was possible to eliminate the proposed new boiler, which would have been a considerable investment as the capacity involved amounted to approximately 550 H.P.

Therefore, it is seen that it is not only possible to reduce the fuel bill by knowing where to look for wasted energy losses, but there are many opportunities for keeping the capital investment down to the proper figure by making these losses a minimum.

Another value to an investigation of this kind is that, knowing all the facts as they exist regarding the consumption of power and when the peaks occur during the twenty-four hours, it is often possible to make a few changes in the operation that will smooth out the high peaks, thus making the load more uniform and increasing the production output of the plant without the use of more machinery.

Leakage and Radiation

One other step in the process of economy that generally applies to industrial plants is that dealing with the losses incurred through leakage and radiation. These losses should be watched very carefully and when discovered should not be allowed to continue, as the amount of energy wasted by these two items is sometimes surprisingly large.

To determine how "tight" a plant is, a leakage test on water or steam piping should be made on the entire plant during some period when the plant is not in operation. Usually a holiday is chosen for this purpose. By using a totalizing meter, the amount of leakage on the water system can be observed while maintaining the regular

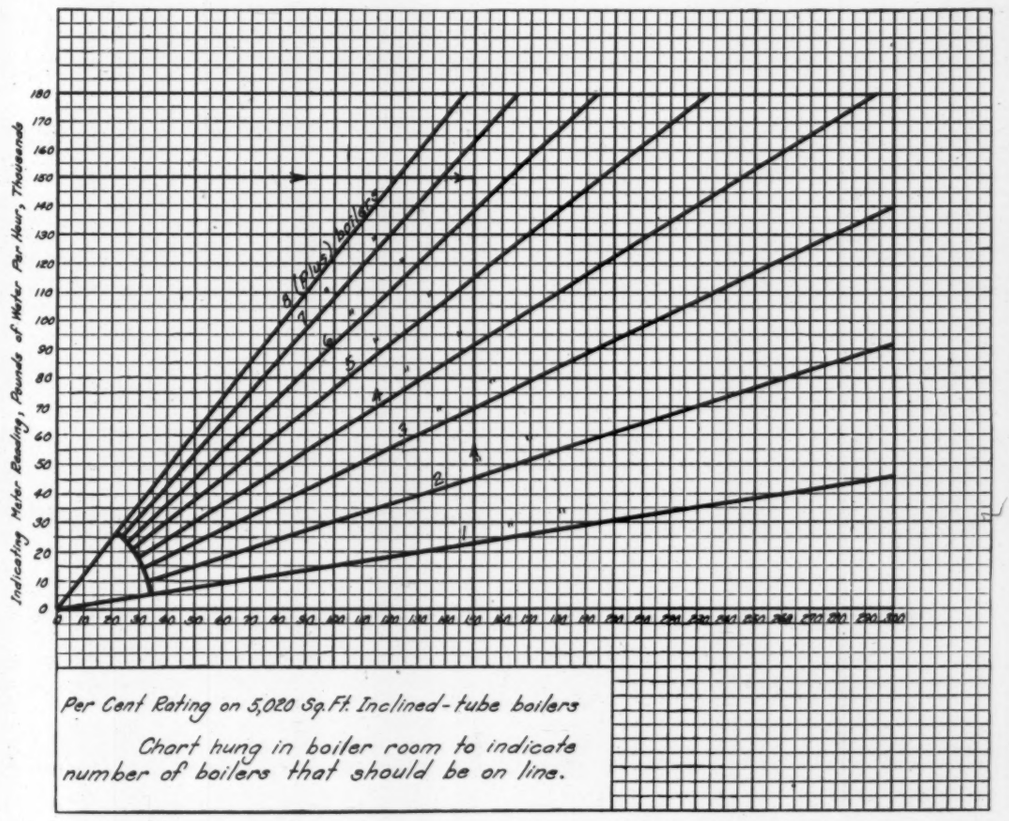

Indicating Water Reading, Pounds of Water Per Hour, Thousands
Per Cent Rating on 5,020 Sq. Ft. Inclined-tube boilers
Chart hung in boiler room to indicate number of boilers that should be on line.

FIG. 2.—A CONVENIENT FORM FOR DETERMINING THE NUMBER OF BOILERS TO CARRY ON THE LINE.

pressure on the lines that is necessary when the plant is in operation.

The same method is used as mentioned above for water in determining steam leaks and radiation losses, with the exception that both radiation loss and steam leaks through pipe joints, steam traps, valve stems, etc., are determined as a single item and can not be separated without considerable effort and expense. If the separation of the particular item is desired, then it is necessary to go over the plant and stop all visible steam leaks in the piping system, steam escaping to the atmosphere from water heater exhaust heads and any waste in steam trap discharges. When these leaks have been stopped, then, by difference, any feed water used to supply the boilers to keep a normal level in the gauge glass should represent the amount of steam wasted in the plant by radiation. This test should be carefully conducted and over a sufficient period of time, such as 10 or 12 hours, to give fairly uniform and reliable results.

Good pipe covering is a paying investment and careful consideration should be given to the kind selected. It is not only the initial insulating value of the covering that is important, but what it will do as an insulator years after being applied. Tests can be made to show that many grades of covering deteriorate in insulating value in a comparatively few years after being applied.

Steam traps are often responsible for considerable waste of steam from a plant. When it is considered that a trap having an inch and a half steam inlet is capable of handling the condensation from 18,000 square feet of radiating surface, or approximately 6,000 pounds of steam per hour, it is easily seen that steam traps should be tested frequently. They should be maintained in the proper state of operation to prevent steam blowing through them, especially if the discharge is connected to the sewer which is sometimes the case.

Utilizing Exhaust Steam

Prime movers offer deep thought regarding their proper selection for a given duty, as the number of types of prime movers available is many. A complete knowledge of a plant cycle, load and power distribution is necessary before attempting to select the right unit.

In many cases in the past, plants requiring as high as 50 per cent of the fuel pile have been equipped with condensing type steam engines, and in many of these cases the heat of the exhaust from the units is wasted from the system either by allowing the water from the condensers to go directly to the sewer or else by dissipating the heat to the atmosphere by discharging the condenser water over a water cooling tower or spray pond.

For Process Work

In plants where considerable steam is required for process work—for heating water, for steam cooking, for drying, etc.—it is well to consider equipment that is not confined to a very limited range of exhaust or back pressure. At the same time, even with equipment in which the range is from 5 to 12 pounds steam of these pressures can quite frequently be used in many cases for process work where higher temperatures are not essential.

Keeping in mind that the total heat in low pressure steam—that is, steam between 5 and 12 pounds—contains approximately 90 per cent of the total heat contained in steam ranging from 125 to 150 pounds pressure, it is seen that there are many cases where low pressure steam can be used for process work or heating if adequate surface is available to make use of this heat. To obtain this surface it means that the number of heating coils may have to be increased in number and the supply headers increased in diameter to transmit the required volume without appreciable loss in pressure due to friction.

For Heating Water

Heating water is often a very profitable way of recovering heat that would otherwise be wasted because the steam, or even the hot water, carrying away the heat is ladened with impurities such as alkalis, soap, oil or grease, and thus can not be put directly into the boilers or house supply heaters. Under these conditions a heat recovery apparatus, often referred to as a heat exchanger, should be given consideration. These exchangers are arranged to absorb heat contained in gases, waste hot water or exhaust steam escaping from the system, and when it is considered that in raising the feedwater entering the boiler 10 degrees, a corresponding saving in the coal pile of 1 per cent is made, it is obvious that wasted heat should not be permitted. There are on the market today many forms of heat recovery apparatus, preheaters, etc.

Right Piping Essential

Piping plays its important part in good plant operation. In many cases it is responsible for loss in economy not only through leaks, quick deterioration and radiation, but also through being improperly arranged, not properly drained or trapped and many times because of inadequate carrying capacity. This is especially so when the pipe line is carrying low pressure steam where a drop of one or two pounds on a 10 or 12 pound line means a large percentage.

This also applies to hydraulic service where the effect of pressure is important in accomplishing the purpose in mind. If the drop in pressure is appreciable, then the quantity of water thus used is correspondingly increased to do the same work that a higher pressure supply would accomplish with a lesser volume. In many cases, considerable of the friction can also be reduced by selecting the proper valves and fittings, and by reaming the pipe ends, which often are cut to fit by hand in the field during the process of erection, with the result that many burred ends might go into the job.

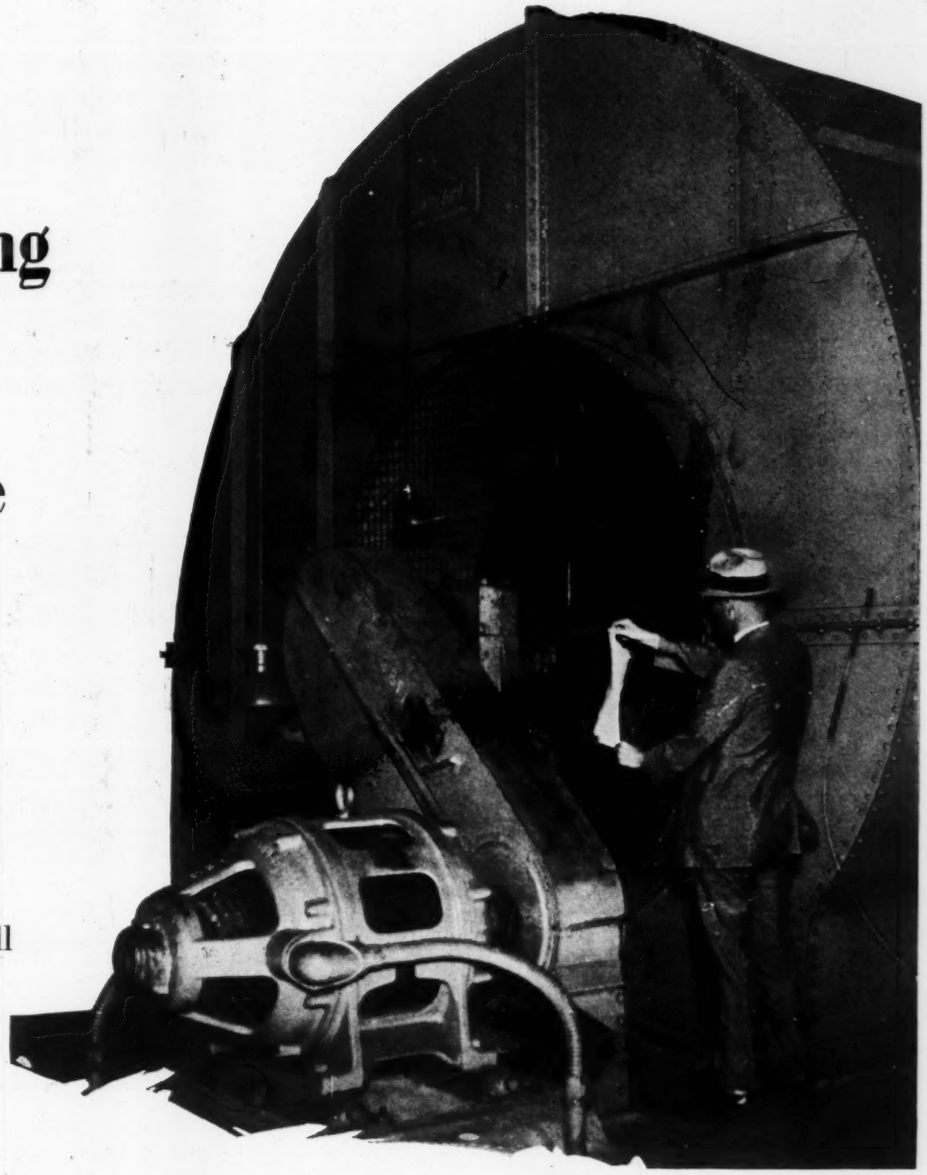
Having all the information indicated above gives the plant owner, production manager and operating engineer the opportunity to work the motive power department on a budget system, which, if sensible for other departments of the business, by the same token is applicable to this one.

There are many places, it is evident, where waste can occur, from the generation of the energy through every detail of its distribution and utilization. The way to stop them is to know them. Know what the load requirements are for the operation of the plant. Then, keep a check on the consumption. When it exceeds standard requirements, it is obvious that somewhere along the line there is waste. That is why a budget system can be made to work to advantage.

Air Conditioning

Its Future *in the* Field *of* Human Comfort

By Dwight D. Kimball



IS THE art of air conditioning advancing? If so, when did it begin its advance, and how did it advance? By what steps? Why and where? Such are the questions to which an answer will be attempted.

Certainly air conditioning is advancing, gradually in an engineering sense, by leaps and bounds in a commercial sense. In both senses, however, the rate of advance of the last ten years exceeds that of all previous time.

Basically, air conditioning by man began when artificial heat was first provided for human comfort. But that is about all that was done for many centuries.

Since the earliest days of medicine, the harmful effects of bad air and the benefit of good air have been recognized. There was the early miasmatic theory of bad air, then the recognition of "the igneoaerial particles of the air" in respiration as conceived by Mayon in the seventeenth century and defined by Lavoisier a hundred years later, who in 1777 began the study of oxygen and carbon dioxide. Following this for about a hundred years the carbon dioxide theory prevailed in ventilation. Then came the theory of Max von Pettenkofer (1862-3) who first established the conclusion that bad ventilation should be charged to other factors than carbon dioxide. The harmful effects of bad air and the beneficial effects of good air later led to the erroneous theory of hypothetical toxic organic substances in respired air. Then came the recognition of the work of Hermans (1883), Flügge (1905) and Hill (1913) proving that the thermal rather than the chemical properties of the air are of vital importance in connection with ventilation insofar as normally occupied spaces are concerned.

Many others there were who, in these latter years, contributed to the steps of progress. Early in 1912, during the annual meeting of the American Society of Heating and Ventilating Engineers, a general conference of many persons interested in the problems of ventilation was called to determine whether any general agreement could be had upon the fundamental require-

ments of good ventilation, and no agreement was possible. There resulted, however, largely from this meeting, the work of the Chicago commission on ventilation, the work of the New York state commission on ventilation and its existing successor, the New York commission on ventilation, the establishment of the research laboratory of the American Society of Heating and Ventilating Engineers, the studies of the bureau of public health, of the Carnegie Nutrition Laboratory, at Harvard, and at other universities, and many others. Much progress has been made but there are still problems ahead.

For those who desire a detailed history of the studies of ventilation, reference may be had to the report of the New York State Commission on Ventilation (1922), "Ventilation," by Prof. C. E. A. Winslow, or "Review of literature on the physiological effects of abnormal temperatures and humidities," by R. R. Sayers and Sara J. Davenport, Reprint No. 1150, from the Public Health Reports (April 8, 1927).

The Interrelation of Temperature, Humidity and Air Motion

Along with the recognition of the importance of the thermal properties, studies on air temperature began. It was soon realized that temperature was linked with humidity, and then that the effect of both temperature and humidity were modified by varying degrees of air motion. A change in any one of these three factors requires a change in one or both of the other factors to produce an equal sensation of comfort, and there are reasonably definite limitations of each of these factors, and of combinations thereof, which may be said to be within the limits of human comfort. Hence the evolution of the comfort zone chart, first conceived and developed by Dr. E. Vernon Hill and later modified and approved by the research laboratory of the American Society of Heating and Ventilating Engineers. This is a graphic chart combining the factors of temperature and humidity, and is arranged for different air velocities. The chart for still air conditions is shown in Fig. 1.

Heat Balance the Main Object of Air Conditioning for Comfort

Air motion will cause any moderate air temperature to feel cooler to the human body. Human comfort, as regards atmospheric surroundings, depends primarily upon body temperature, and hence upon the relation of heat production and its dissipation. Heat is generated within the human body through the process of metabolism. It is dissipated from the surface of the body and through the respiratory tract by convection, radiation and evaporation. A constant body temperature is maintained so long as the production of heat and its dissipation are balanced.

When the temperature of surrounding air and objects increases, loss of heat from the body by convection and radiation decreases until the surrounding temperatures equal the body temperature when they cease entirely, after which the body attempts to maintain a heat balance by increasing evaporation, in which air movement becomes an important factor.

Thus may be seen the interrelation of temperature, humidity and air movement in relation to the effect of one or all of these factors upon human comfort. These relations, when charted in the form of graphs for different air velocities, result in a psychrometric, or comfort zone, chart.

Of the desirability of clean air—air free from dust and bacteria—there can be no question. Under many conditions, dust in air is not regarded as a matter of importance, although in public buildings in cities, for instance, the air cleaner is usually a part of the air conditioning equipment.

The elimination of dust is of importance in many industrial processes, both because of its character and amount but only in densely occupied spaces do airborne bacteria become a matter of concern to the air conditioning engineer.

A general agreement may be said to have been reached that a correct temperature, with certain limitations on relative humidity, with a proper degree of air movement, and reasonably clean air may be used as a basis upon which air conditioning can be undertaken with an expectation of general satisfaction. Upon such a basis has the work of the last decade been carried forward.

Meantime comes the discovery that in schoolrooms ventilated through open windows, in combination with gravity exhaust flues, there seems to be some quality of the air that, to many persons, seems preferable to the air supplied by mechanical ventilating systems, and there is some evidence offered that the incidence of respiratory diseases is less in the window ventilated schoolrooms. The explanation of this apparent condition is not yet available. The theory has been advanced that it may be due to the de-ionization of the air while passing through the metal ducts of the mechanical ventilating system. This theory is now being studied by Prof. Earle B. Phelps and by others.

However, the basis of a general agreement as to the most desirable condition of the air for densely occupied spaces seems to be in hand, and to provide such air is but a mechanical detail to the air conditioning engineer.

Ventilation (which, as practiced, is air conditioning) was first generally applied to school buildings, then to auditoriums, and to industrial establishments. But only rarely did such ventilation include the cleansing and humidification (or dehumidification) of the air.

To anyone who appreciates the merits of ventilation, as a health producing agency, as a means of improving efficiency, and perhaps as a means of lessening the incidence and prevalence of certain respiratory diseases it appears strange, and even remarkable, that the highest type of ventilating systems, including humidification, dehumidification and cooling, was first applied to industrial establishments, and that it was in this field that the most rapid progress and the widest use of such systems have been made.

Complete ventilation, or thorough air conditioning, first evolved for human comfort, appears to have been more highly regarded as a means to more and better products in the factory.

Next the theater owner awoke to the commercial or box-office value of a well ventilated and cooled theater in the summer, for clearly it is only indirectly that the comfort or welfare of the theater patron has developed the tremendous business of installing theater air condi-

tioning, or cooling systems. Similarly, although to a less extent, the hotel proprietor has awakened to the potentialities of properly ventilated and cooled dining rooms, restaurants, ball rooms, etc., as this relates to the profit sheet.

Department stores are just beginning to awake to the possibilities of increased patronage induced by cooling the sales rooms in the summer.

Not in one of the classes above cited is human comfort or welfare the basic consideration leading to the installation of air conditioning and cooling plants.

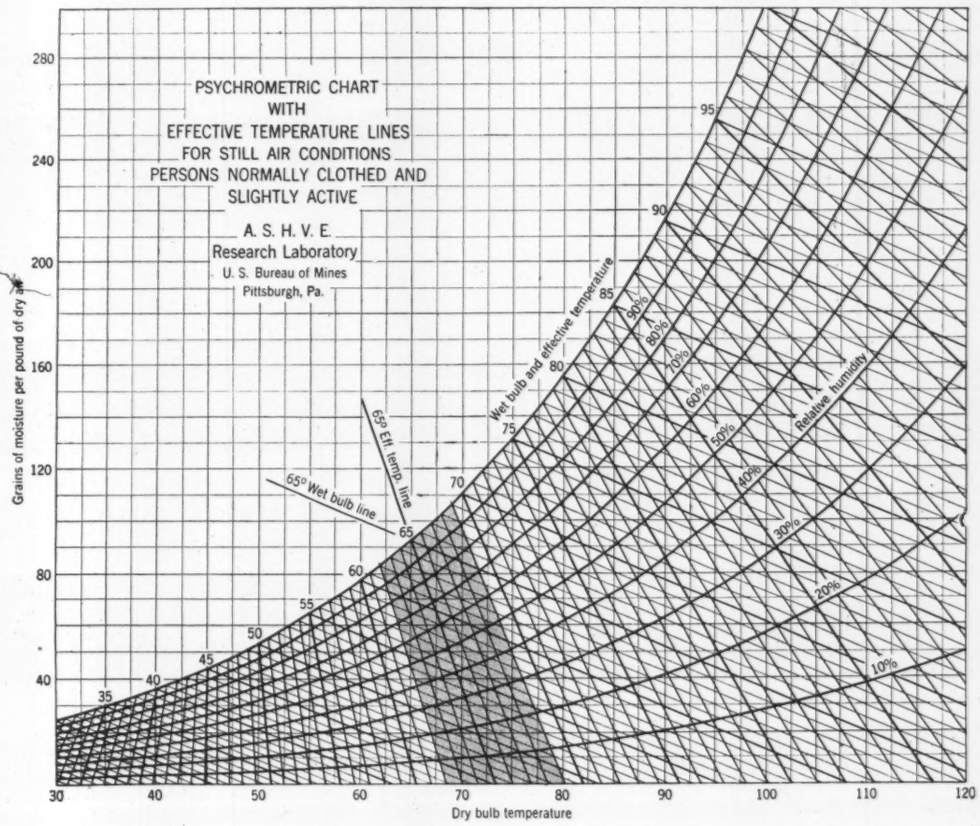


FIG. 1. PSYCHROMETRIC CHART WITH EFFECTIVE TEMPERATURE LINES FOR STILL AIR SHADED AREA INDICATES THE COMFORT ZONE

Air Conditioning for Comfort

A few isolated cases of real air conditioning, including cooling systems, might be cited in commercial offices. To what extent the comfort of the workers influenced these installations may be left to conjecture.*

A very few small cooling installations have been made in hospitals, usually to serve one or two rooms.

Of air conditioning and cooling systems installed to serve apartment buildings (tenants' rooms) the writer knows nothing. Private homes in this country equipped with cooling plants may be counted upon the fingers of one hand, and very few homes have any artificial ventilating equipment.

In industrial establishments, the purpose of installing air conditioning systems is to provide such temperatures and humidities as will facilitate the processes of manufacture to the greatest degree, usually requiring fixed temperatures and humidities, involving sometimes heating and at other times cooling, at times requiring humidification and at other times requiring dehumidification. The comfort of the workers is usually a secondary consideration.

In theaters, public rooms in hotels, department stores, etc., the conditions to be maintained are determined with a view to the maximum comfort of the patrons. The most generally accepted standards are as follows:

For winter:

Occupied spaces to be warmed to 70 degrees F. relative humidity to be maintained between 30 per cent and 50 per cent.

For summer:

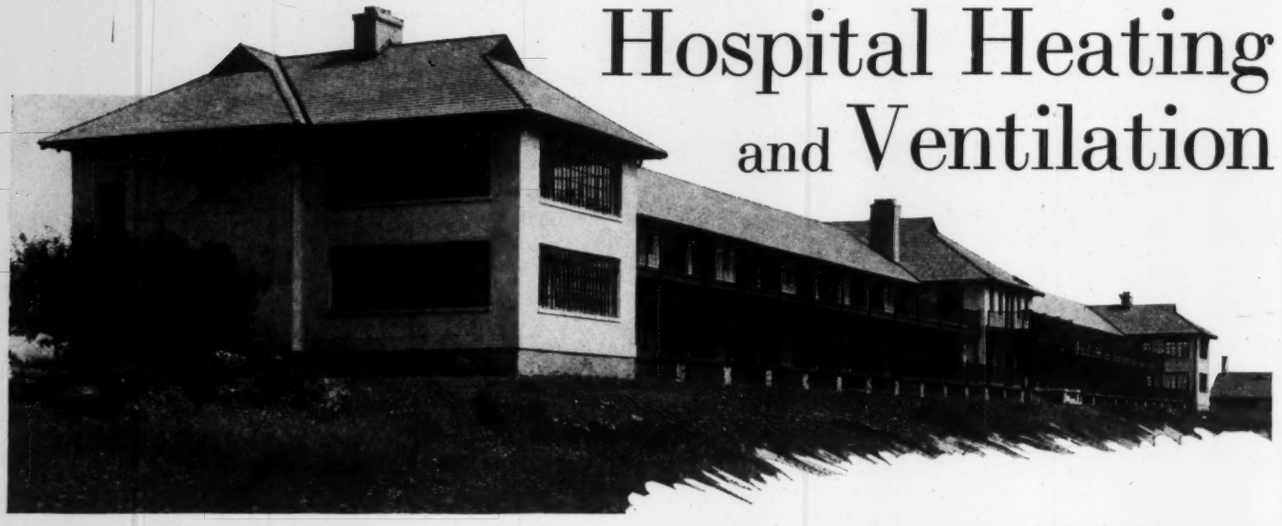
Occupied spaces to be cooled to a temperature not in excess of 75 degrees F. Relative humidity to be maintained between 30 per cent and 55 per cent even though the outside dry bulb may reach 95 degrees F. and the outside wet bulb 78 degrees F.

The above may be taken as a basis of determining capacities and for guarantees, but an inside temperature which is more than seven to eleven degrees below the outside temperature is rarely desirable.

Within the last fifteen years, greater progress has been made in definitely determining the exact requirements of good ventilation and air conditioning, in refining the methods of application, and in the growth of installation of real air conditioning systems than in all time previously. Only minor refinements of equipment seem to be immediately in view.

*(*An outstanding example of the application to an office building of air conditioning for human comfort alone, is the recent installation in the Title and Trust Building, Chicago, which is described in an article in this issue.—The Editor.)*

Hospital Heating and Ventilation



S. W. and Nette Bowne Tuberculosis Hospital, Poughkeepsie, N. Y. Edward C. Smith, Architect, Offner & McKnight, Consulting Engineers
A hospital or ward for tubercular patients presents special demands in heating and air conditioning

By **Alfred J. Offner, M. E.**
Offner & McKnight, Consulting Engineers

PROBABLY in no other branch of heating, piping and air conditioning can the engineer and contractor employ their knowledge, skill and experience to a better and more worthy cause than in the heating and ventilating of hospital buildings. Where can they apply the spirit of the good Samaritan more advantageously than doing their part in alleviating the sufferings of those who unfortunately are bodily or mentally sick?

When one considers that a hospital building may be either for general use, both medical and surgical, or may be used for special purposes, such as psychiatric, tuberculosis, contagious, maternity, cancer, etc., one realizes that the subject of heating and ventilation of hospitals is varied and of special application. Therefore, an article as limited in length as this can only be a broad general discussion of the subject.

The type and extent of the heating and ventilating system to be provided not only depends on climatic conditions, but also on the location, size and the use of the hospital building.

Types of Heating Suitable

The principal consideration, in hospitals where artificial heating and ventilation is to be provided, is the maintenance of a suitable temperature, cleanliness, the provision of properly conditioned air and the removal of vitiated air in the principal rooms, and the avoidance of injurious drafts.

It should be remembered that overheating, while distressing to persons in good health, is more so to those in ill health, especially to those unable to help themselves. Overheating is also very harmful to one's health. Its prevention is, therefore, of vital importance in hospital buildings.

As mild heat is more agreeable, wholesome and healthful, and does not result in dry distillation of dust, heating by water would seem highly desirable for hospitals, even with its disadvantages, as claimed by some, of lesser flexibility to take care of sudden outdoor temperature changes, which objections can nearly all be overcome by proper and intelligent design and operation. Heating by water permits central regulation of the water temperature to suit varying weather conditions, preventing overheating and resulting in fuel economy.

When water is the heating medium being used, additional boilers must be installed to take care of the steam requirements for kitchen, laundry, and hospital apparatus, and also for the heating of water for domestic uses. The additional water heating boilers may be eliminated if steam heated convertors are used for heating the water.

When the heating is to be done with steam, one type of boiler may be used both for heating and for domestic hot water, kitchen, laundry and hospital apparatus, the steam pressures being reduced for the various purposes.

When the steam required for heating is being circulated near atmospheric pressure, the radiators located in the principal rooms should be provided with automatic temperature control. The nurse or attendant should not be expected to watch the room temperature and manipulate radiator valves.

Recent developments have been, and are being, made in improving heating by steam, especially as applied to larger systems. By them the generation and distribution of steam at sub-atmospheric pressures is accomplished, permitting a larger range of working pressures, and a correspondingly greater variation in the temperature of the steam than has been possible before, although the great temperature range obtained with heating by water has not yet been reached. Other developments provide, according to weather conditions, for the central control by automatic regulation of the amount of steam be-

ing supplied to each radiator. The radiator temperatures in such a system correspond to steam temperatures at or near atmospheric pressures. Further developments in these directions may make these systems quite desirable for hospital heating.

Location of Radiators

To obtain most efficient and healthful heating, radiators should be exposed and be placed under the windows. Furthermore, the radiating surfaces should be shallow and be well spread under the entire width of the window. Such a location and arrangement tend to make best use of both the radiating and convected heat given off by the radiator, contributing to a more uniform room temperature and more comfortable conditions with lower air temperatures. Short and more confined radiators, especially if placed along inside walls, have a tendency to create higher ceiling temperatures with lower temperatures at the breathing line, and the possibility of creating drafts.

As cleanliness is of highest importance in hospitals, radiators should be hung on the walls and the radiator connections be brought through the walls, above the floor, so as to permit a clear sweep under them. For the same reason, radiator sections should be so spaced that they can be easily cleaned.

Radiators in hospitals that are enclosed or screened present the possibilities of not being kept clean, and also present opportunities for the collection and drying of dust and its distribution into the air. Some concealed and screened radiators also have a tendency for overheating the ceilings and creating uneven temperatures in the room. Concealed radiators are really no longer "radiators," but become "convectors."

There are certain special cases, such as rooms for violent or irresponsible patients in psychiatric hospitals, where radiators must be enclosed as a precaution to protect the patients against possible injury. In cases where no grilled openings for the circulation of air are permitted, some form of plate or panel heating is indicated. Where grilled openings are permitted, the enclosures must be easily removable for cleaning purposes.

Locating exposed piping in the rooms used for the treatment and care of the patients, for reasons of cleanliness and possible overheating, should not be permitted in hospital heating systems, engineers agree.

One of a group of buildings for Bloomingdale Hospital, White Plains, N. Y. An example of desirable location to get the benefits of plenty of air and light

Grosvenor Atterbury—John Tompkins, Architects, Offner & McKnight, Consulting Engineers

Room Temperatures

When one considers that every hospital not only has patients in all conditions of dress and undress, but also in all states of physical and mental sickness, it is to be expected that different rooms will require different temperatures. The 1929 issue of the Guide of the American Society of Heating and Ventilating Engineers gives a table of room temperatures usually specified for hospitals, and which is repeated in Table 1.

The patients' sleeping rooms in tuberculosis hospitals are generally not provided with heat. Living rooms, dressing rooms and baths in these hospitals are heated to 70 degrees F. In hospitals having hydrotherapy departments, steam baths are usually heated from 110 degrees to 115 degrees F., and warm air baths from 120 degrees to 125 degrees F.

The Necessity of Ventilation

Air, together with water and food, are the three indispensables of life. Like the latter two, air must be pure, wholesome and clean to be of maximum benefit. As properly conditioned air will help to bring health to those of weakened vitality, so dusty, overheated, vitiated air may bring sickness to those in good health. Consequently, the adequate supply of air of proper quality to those bodily and mentally ill, whether furnished by natural or artificial means, is of vital importance.

By nature of their uses, hospital buildings, wherever possible, should be located in sections away from noise and dust. The orientation of the building should be such as to give the principal rooms the best location as to sunshine and prevailing winds. The rooms for the care and treatment of patients should be located and arranged so that the maximum ventilation can be obtained by natural means. While such ideal locations and arrangements can and should be expected in country and suburban sections, the choice of site and arrangement is limited in urban districts.

Natural Ventilation

To permit convenient ventilation by natural means and the occasional "flushing" out of the air in the rooms, windows in hospitals shall be arranged for easy opening and closing, and doors leading into corridors should be provided with movable transoms. But natural ventilation can only be entirely depended upon in warm climates and where a sufficient and positive amount of clean air can be passed through the rooms to give thorough ventilation without objectionable drafts. There are limitations to natural ventilation due to

climatic conditions and location of buildings, making it necessary to provide properly designed and operated artificial ventilating systems.

Artificial Ventilation

Artificial ventilation for hospitals is the process of supplying clean and properly conditioned air and the removing of the vitiated air in rooms where the air may become contaminated by the occupants or by certain processes going on, where a number of persons or patients may be housed or congregated, and where certain psychological and physiological reactions are desired. In rooms where odors, vapors or heat are generated, the air should be removed in a positive manner.

TABLE I
Inside Temperatures for Hospitals

	Degrees, Fahr.
Private rooms	70
Private rooms (surgical)	70—80
Operating rooms	70—95
Wards	68
Kitchens and Laundries	66
Toilets	68
Bathrooms	70—80

It is not the chemical composition of the air that is the important factor in determining good ventilation, but a combination of quality and quantity of air, air movement, temperature and relative humidity.

Overheated air with high relative humidity will lower the vitality of a person and may cause headaches, dizziness and sickness. Overheating air will also reduce its freshness. Furthermore, air coming in contact with surfaces at high temperatures will decompose any organic dust that may be in the air and produce objectionable and injurious gases. Therefore, the temperature and relative humidity of the air should be under automatic control, and the air should not be heated to a high temperature. The best results are obtained if the air is supplied at or near room temperature. Also, the ventilating system should not be used for heating, but the two should be kept entirely separate and independent of each other.

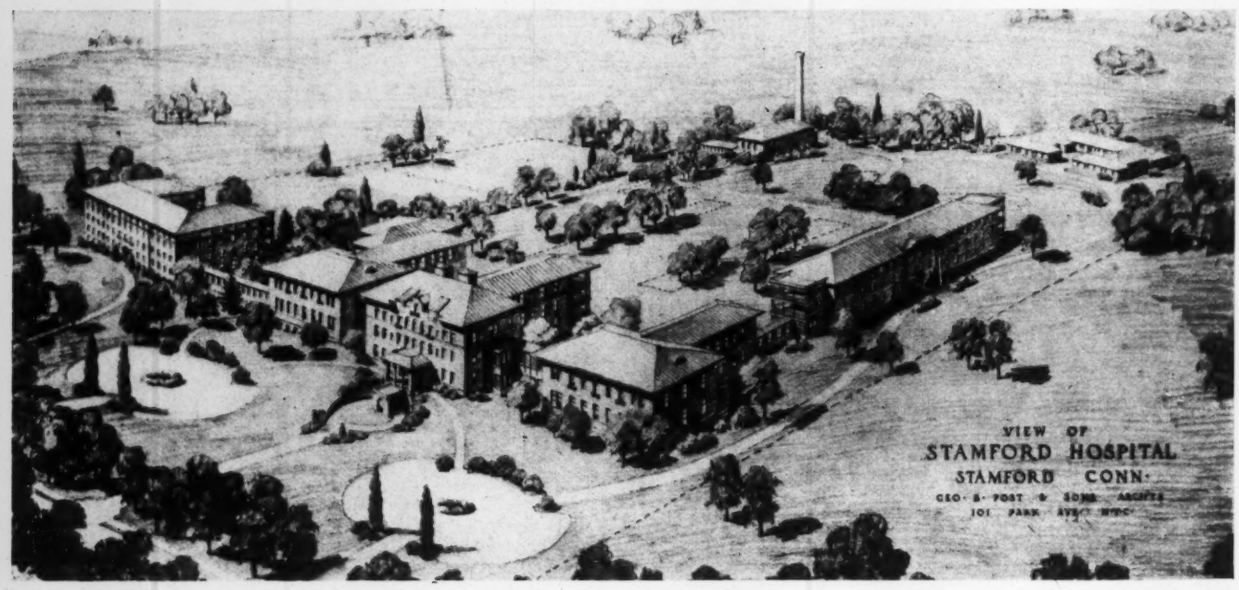
As cleanliness is of great importance, the air should be taken in where it will be free of odors, dust and other impurities, and, as a further safeguard, should be further cleaned by suitable means before being introduced into the building. All apparatus should be so located as to give easy access for control and cleaning purposes. The air ducts and other air passages should be so designed that they will be self-cleaning, also so that there will be no places for dust to collect. The air should preferably be introduced and removed from the rooms through openings without register faces. Where register faces are desired, they are to be of the sanitary type consisting of parallel bars (without the cross bars), so they can be easily cleaned. A ventilating system that is dirty is not only detrimental in every type of building, but is especially so in hospitals.

The air should be supplied and exhausted noiselessly, and special precautions must be taken to reduce the noise made by moving parts of fans, motors, etc., to a minimum.

Quantity of Air

The quantity of air to be supplied and exhausted from the various rooms depends somewhat on arrangement and location, use of the room, and the cubic feet of space provided per occupant.

Private rooms containing one or two patients are generally not provided with artificial ventilation. Large wards should be ventilated. For ordinary wards, it is usual to provide 40 to 60 cu. ft. of air per minute per occupant, for surgical wards 60 to 100, for contagious wards 100 to 150, and for epidemic wards 100 to 150 cu. ft. For operating rooms about 100 cu. ft. of air per minute per occupant is provided. Rooms where heat, vapors and odors are produced are generally provided with exhaust ventilation only. Such rooms may be provided with from 10 to as high as 60 changes per hour, depending on the size, location and use of the room.



A View of the Stamford Hospital, Stamford, Conn.

FIG. 1.—AIR VIEW OF UNIVERSITY OF WASHINGTON CAMPUS

Heat—With *or* Without Power

By E. O. Eastwood *and* G. S. Wilson

SINCE the advent of the public utility corporation and especially since the adoption of the more recent aggressive policy of public utility companies, both public and private heating and power plants have had to show cause for their performing the services for which they were established.

The experience of the University of Washington furnishes a new solution of an old problem. Assuming a demand for exhaust steam, does it pay to generate electric energy, or should such energy be purchased and the local plant be operated as a heating plant only? Anyone versed in engineering principles would be apt to infer that when there is a need of power as well as a need for heat, the simultaneous generation of both would be economical. This principle of engineering is laid down in text books and has been proven correct in many instances, and yet any engineer will admit that the contributing factors in a special case are so variable as to require a study of the case in question without prejudice. Unless there is a reasonable balance between the power and heating loads the answer to the problem is obvious. If the heating load is disproportionately greater than the power load, the answer seems obvious, but only a few cases may be so designated without analysis.

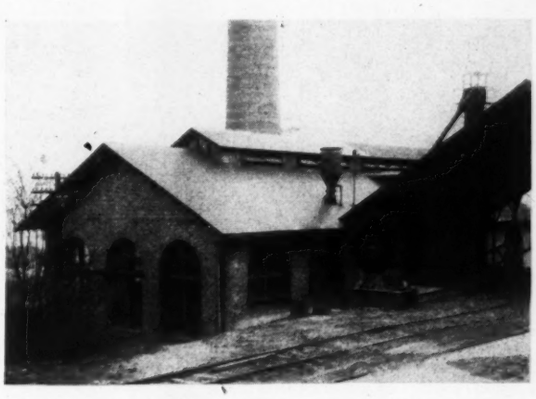
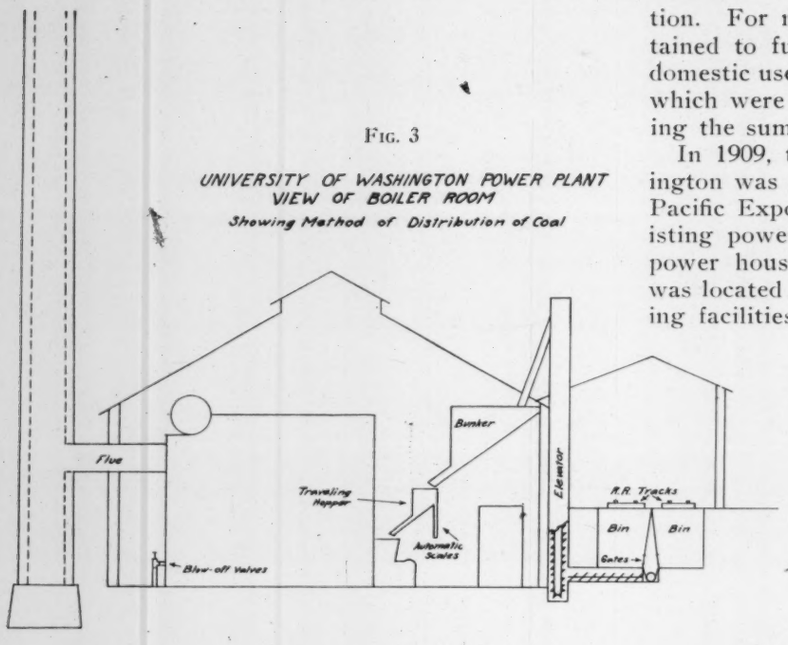


FIG. 2.—POWER HOUSE, UNIVERSITY OF WASHINGTON

Growth Increases Heat and Power Demands

The University of Washington is typical of many western institutions in that its size is the result of a rapid growth not contemplated in its early history. It has increased in enrollment from 1,000 in 1905 to 8,000 students in 1929. Its

FIG. 3



physical plant has been added to as demand arose instead of being originally designed for its present use.

In 1902 the University moved its site, but not its buildings or plant, from the center of Seattle to the suburbs of Seattle and established its campus upon a tract of 360 acres bordering Lake Washington, which is 25 miles in length. An abundant supply of fresh water was therefore available. The average height of the campus above the lake level is 75 feet.

The first group of buildings constructed on the new site consisted of a recitation hall, two dormitories and a power plant. The latter was located at the edge of the lake, a distance of 1,200 feet from the group of buildings. A small generator was installed and a steam main was laid in bored log conduit. At that time, no power nor heating service was available from an outside source. Two other power plants have been constructed since the initial construction, and until the past year the University was entirely dependent upon its own plant for power and heat. The contamination of lake water and the availability of pure water from the city made it advisable to discontinue all pumping even for irrigation. For many years a pumping plant was maintained to furnish water to laboratories, for certain domestic use and to supply over a hundred sprinklers which were practically in continuous operation during the summer season.

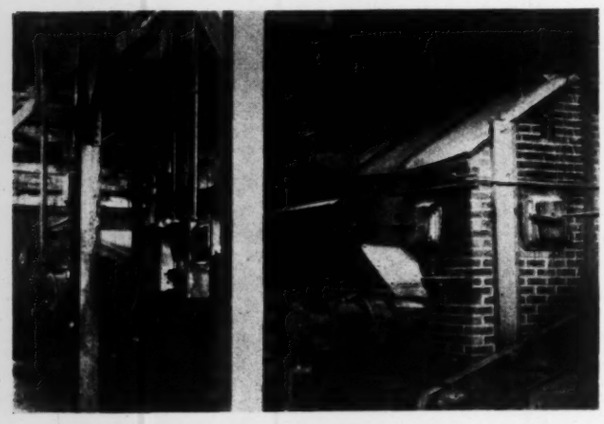


FIG. 5.—TWO 500 H.P. WATER TUBE BOILERS, UNIVERSITY OF WASHINGTON

In 1909, the campus of the University of Washington was chosen as the site of the Alaska-Yukon-Pacific Exposition, requiring the removal of the existing power house and the construction of a new power house and distributing system. This plant was located so as to provide for ample railroad hauling facilities. All fuel had previously been hauled with trucks. Provision was made for the removal of ashes by sluicing. Two 300 h.p. water tube boilers were installed; two automatic high speed simple engines were installed, and an 18-inch exhaust main provided to connect with the previously installed 12-inch heating main. The old main was constructed in a tunnel. A tunnel was subsequently constructed for the new main from which laterals in wooden conduits led to the buildings to be serviced. Later, two additional 300 h.p. water tube boilers were installed, and, as there was an abundant local supply of fair quality sub-bituminous coal available, chain grates were installed under the new boilers corresponding to the present equipment.

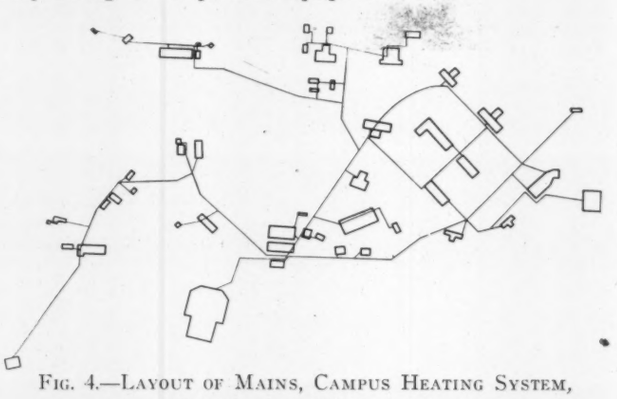


FIG. 4.—LAYOUT OF MAINS, CAMPUS HEATING SYSTEM, UNIVERSITY OF WASHINGTON

Natural draft was provided by a 150-foot stack, 15 feet in diameter. Soon after the plant was constructed, a uniflow engine of 500 h.p. rating was installed. The exhaust pressure was ordinarily maintained at 7 lb. per square inch to insure sufficient pressure for heating the farthest buildings half a mile distant from the power house. The operating boiler pressure was fixed at 130 lb. A pressure reducing valve maintained the desired constant back pressure of 7 lb.

The growth of the University required the construction of many new buildings, and those buildings constructed in recent years were equipped with modern heating and ventilating systems. The older buildings were equipped with older systems so that the present entity is composed of practically all types of heating and ventilating systems. Within the past two years, the building program has advanced to such an extent as to tax the capacity of the power plant, both as to boiler and generator capacity. Two

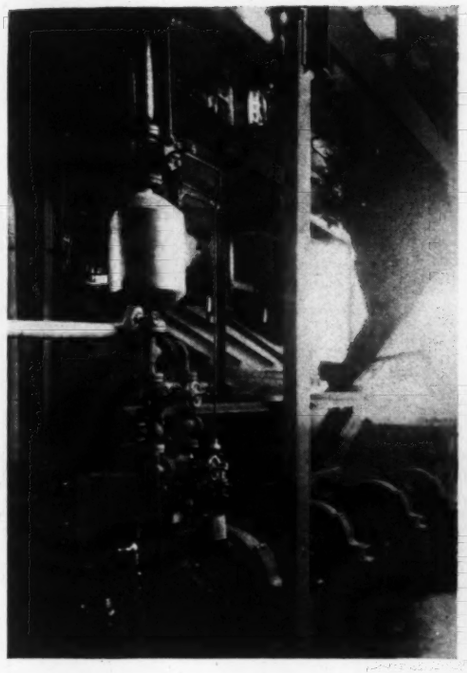


FIG. 6.—BOILER ROOM SHOWING UNDERFEED STOKERS, UNIVERSITY OF WASHINGTON

500 h.p. water tube boilers, with underfeed stokers and forced draft, were installed as it seemed quite apparent that no question would arise as to the advisability of providing heat for present needs as well as for a reasonable future growth. The provision of a generating unit would necessitate building alterations as well as comprehensive changes in equipment. This proposal necessitated a complete test and analysis of plant conditions.

Heating Only—Or Heat and Power?

A proposal was made at this time to supply the power needs of the University from without, with the recommendation that the University plant be run as a heating plant only.

The plant is equipped with an overhead coal conveyor, semi-automatic weighing scales, venturi meter, low pressure steam meters, recording thermometers, CO_2 recorder, watt-hour meters, etc., and is arranged so that a continuous test can be readily made.

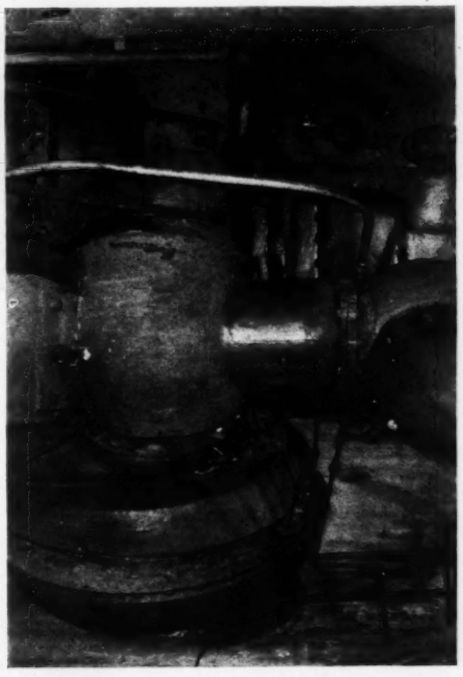
Test Conditions

The two 500 h.p. water tube boilers have a capacity sufficient to carry all of the power and heating load except an extreme demand, so these boilers were selected for the steam generating units.

During the first test period arrangements were made to purchase all electric current and to operate only as a heating plant.

In the second test period current was generated up to plant capacity—about 700 kilowatts—a part of the electric load was purchased. Heat was generated as before.

FIG. 7.—EXHAUST MAIN AND OIL SEPARATOR, LIVE STEAM CONNECTION, UNIVERSITY OF WASHINGTON



Summary of Tests

Heating only — January 17 to February 6, inclusive —21 days.

Equivalent evaporation per lb. of coal as fired, lb.	8.42
B.t.u.'s per lb. of coal as fired	11,485
Average boiler and furnace efficiency, per cent	71.1
Total coal burned, lb.	1,873,680
Total heating load, degree days	415.4
Average lb. of steam per degree day, lb.	38,000
Total cost of fuel—$3,170.00—Cost per 1,000 lb. steam	$0.201
Purchased electric current —159,600 KW. hrs.— Cost	$1,596.00
Total cost of fuel for heating and electric current	$4,766.00

Heat and light—February 7 to February 27, inclusive—21 days.

Equivalent evaporation per lb. of coal as fired, lb.	8.95
B.t.u.'s per lb. of coal as fired	11,935
Average boiler and furnace efficiency, per cent.	72.8
Total coal burned, lb.	1,849,615
Total heating load, degree days	484.8
Average lb. of steam per degree day, lb.	34,120
Total cost of fuel—$3,250.00—cost per 1,000 lb. steam	$0.197
Electric current generated, k.w. hrs.	149,700
Electric current purchased—15,600 k.w. hrs. cost	$195.00
Total cost fuel for heating and electric current	$3,445.00

Labor, Repairs and Supplies

In comparing the results obtained in the two tests, cost of labor, repairs and supplies must be considered. When current is generated, both engine and boiler room crews are needed. Cost of labor, repairs and supplies for 21 days—$1,125.00.

When heat alone is generated, engine room, labor and repairs may be dispensed with. A possible maximum

FIG. 8.—VIEW OF HEATING MAIN AND TUNNEL, UNIVERSITY OF WASHINGTON

reduction of $600.00 for 21 days might be made. Overhead costs when furnishing heat alone—$525.00.

Total costs are then:—

(a) Plant furnishing heat only—$5,291.00.
Time—21 days. Heating load—415.4 degree days.
Light load—159,600 k.w. hrs.

(b) Plant furnishing heat and light—$4,570.00.
Time—21 days. Heating load—484.8 degree days.
Light load—16,530 k.w. hrs.

Without attempting to correct for the larger heat and light load carried during the second period, the net gain was $721.00, or about $950.00 per month.

Engine tests and records from low pressure meters give an average steam consumption of 50 lb. per kilowatt hr. Using the data from the second test period it will be found that about 12 per cent of the steam should be charged to light and 88 per cent to heat.

Fuel cost of generating current when all steam is needed for heating—$0.0012 per kilowatt hr.

Labor charges and repairs—$0.0040 per kilowatt hr.

Cost of generating current per kilowatt hr.—$0.0052.

Purchased current, in quantities, used during test period, will cost approximately $0.0100 per kilowatt hr.

Make Summer Test

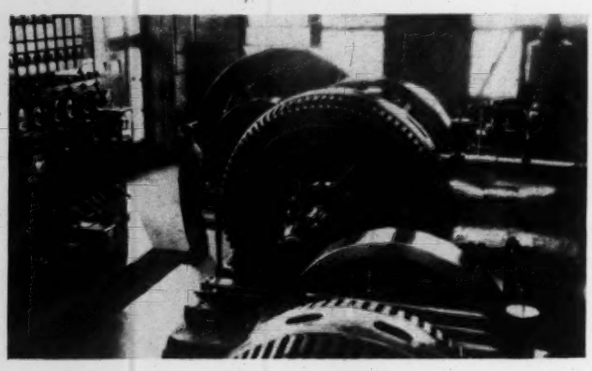
The data indicate that during the winter months, when all exhaust steam is used for heating, it is cheaper to generate current. During the summer period some heat is needed but the light load is in excess of the heating load and it seemed desirable to test the plant during the summer period.

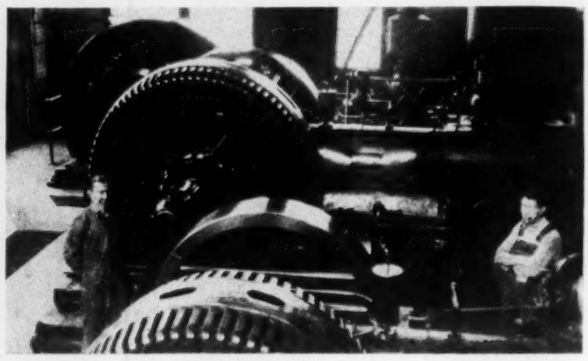
Test—June 25 to July 16, inclusive—21 days.

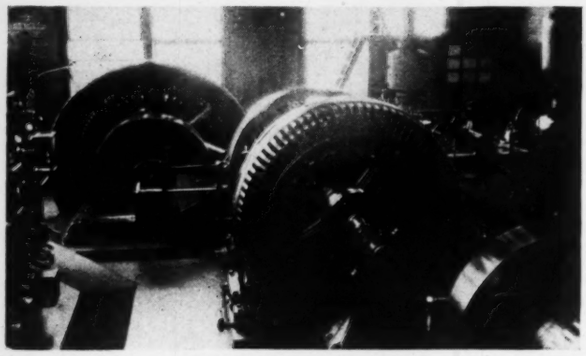
Equivalent evaporation per lb. of coal as fired, lb.	8.50
B.t.u.'s per lb. of coal as fired	11,700
Average boiler and furnace efficiency, per cent	70.3
Total coal burned, lb.	868,420
K.w. hrs. generated	80,000
Total cost of fuel—$1,520.00—Cost per 1,000 lb. steam	$0.208

Steam distribution:

Heating (a) high pressure make up, lb.	351,000
(b) exhaust, lb.	4,006,000
Total steam to heating mains, lb.	4,357,000
Exhaust used by water heater, lb.	730,600
Blow down, lb.	168,000
Total steam used, lb.	5,255,600
Total exhaust to atmosphere, lb.	2,050,400







FIGS. 9, 10 AND 11.—DIFFERENT VIEWS OF ENGINE ROOM, UNIVERSITY OF WASHINGTON

Costs:

Fuel cost—exhaust to atmosphere	$426.40
Fuel cost — steam used	$1,093.35
Electric current—12 per cent exhaust heating steam	$128.30
Total fuel cost of current	$654.70
Fuel cost per k.w. hr.	$0.0068
Overhead (previous tests)	$0.0040
Total cost per k.w. hr. (summer)	$0.0108

All steam unaccounted for (leakage, waste, etc.) has been charged to exhaust. The cost as given is, therefore, the maximum charge that can be made for electric current.

For the quantities used during the summer period the cost of electric current, if purchased, would be about $0.0120 per kilowatt hr.

An analysis of the winter tests indicates that an improvement might be made in the heating load; i. e., during the right periods less heat could actually be furnished if suitable controls were placed on all buildings.

When consideration is given to the fact that various heating systems are in use, that the steam mains aggregate 4 miles of pipe, that 52 buildings are heated, that heating steam is used for heating swimming pool, hot water tanks in all buildings, and showers in both gymnasiums and crew quarters, the use of 3 lb. of steam per 24 hours, per square foot of heating surface is not excessive during the coldest weather.

Summary

The tests showed that the cost to the University for current generated during the heating season was

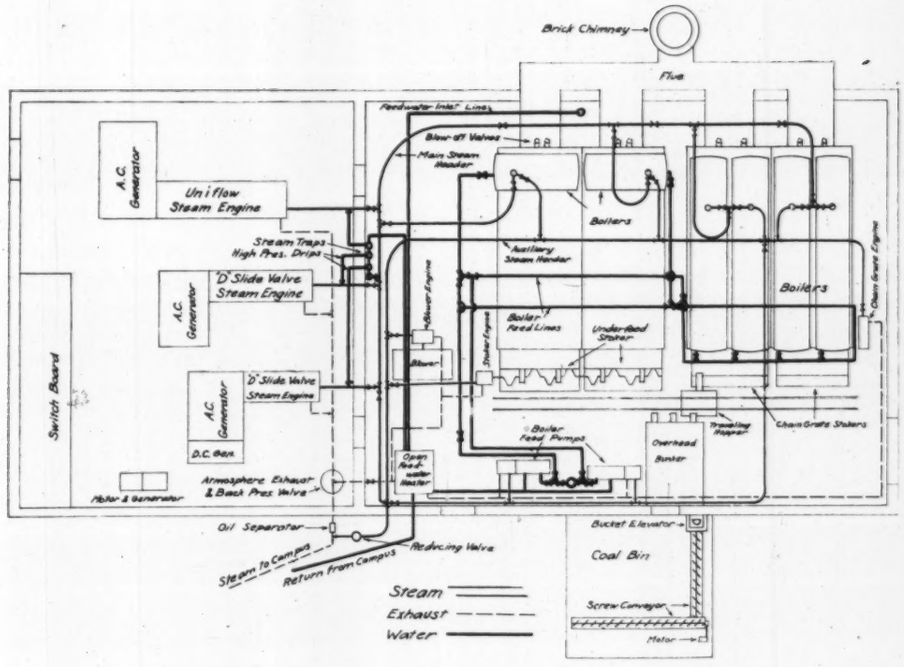


FIG. 12.—PLAN OF POWER PLANT AT UNIVERSITY OF WASHINGTON

$.0052 kilowatt hr. as compared with purchased current at $.0120 kilowatt hr. The cost of generated current during the summer season was found to be practically the same as the cost of purchased current, $.0108. Annual saving operating as a power and heating plant was found to be approximately $7,000 compared with the cost of operating the plant for the purpose of heating only.

Heat Losses from District Steam Lines

ATTENTION is called to essential data on heat loss from underground steam lines brought out in a paper presented by Prof. C. H. B. Hotchkiss at the district heating school conducted at Purdue University.

The object of this paper was to recall the basic facts upon which the loss of heat energy from underground steam lines depends. Essentially this loss is a transfer from the steam to the atmosphere in exactly the same way as is the loss from a similar line carried above ground. The difference between the two cases lies in the fact that ground, or soil, is one of the materials through which the heat must pass from underground lines on its way to the atmosphere.

As the most recent data bearing on the question of suitable methods of calculating the heat losses from underground steam lines for design purposes, and of methods for selecting coverings of suitable thickness for such lines, are contained in two papers presented before the National District Heating Association at its 1927 meeting, attention was turned to the methods outlined in these papers. The papers are by Heilman and by McMillan. The following numerical example was worked out using these methods so far as seemed practicable:

"A 10-inch pipe carrying steam at a temperature of 450 deg. fahr. insulated with 2 inches of No. 1—85 per cent magnesia covering, is carried in a 15-inch (inside diam.) concrete pipe (20-inch outside diameter). This line is buried in the ground and provision is made for keeping the insulation dry."

When solved by these methods the resulting loss was found to be 86 B.t.u. per hour per sq. ft. of pipe surface.

Exactly the same problem was then solved using this 10-inch line in a rectangular concrete conduit with an air space between the covering and the surface of the conduit. This resulted in a loss of 91.5 B.t.u. per sq. ft. of cover area per hour.

In each case, the analysis showed that the cover presented approximately three-fourths of the resistance to heat-flow interposed into the path of the heat current.

An interesting point brought out by these authors lies in their conclusion that for the ordinary case of underground steam lines a rough rule is that the economical thickness of covering is about ½ inch less than for similar lines carried in the air above ground.

The paper closed by calling attention to the fact that the problem of preventing the loss of heat from steam pipes carried underground is not wholly solved when a cover of suitable thickness has been provided, since the presence of water in most coverings causes them to lose their heat-insulating properties. The problem of keeping the covering effective after installation, would appear to be of more practical importance in operation than is the problem of deciding upon the type and thickness of covering before operation starts.

National Standardization of Piping

By Sabin Crocker

WE LIVE in an industrial age whose prosperity is based on the mass production of identical articles made possible by standardized manufacture and use. In this system, dimensions are standardized to secure interchangeable fit, quality is standardized to secure uniform materials, and unnecessary sizes are eliminated to reduce the number of items manufactured and stocked.

Standardization in its broader sense is not a suppression of originality in design or of advancement in the art to which it is applied. It is, rather, a means of making industry function more efficiently by eliminating lost motion, and is a natural outgrowth of the change from making articles by hand to the present machine age in production.

"Standardization is dynamic, not static. It means, not to stand still, but to move forward together."[1]

Standardization had its inception in the efforts of individual plants to reduce hand fitting by producing interchangeable parts for assembling the article which each manufactured. This required setting up a system of inspection, the development of master gauges and working gauges for checking dimensions, and the control of the physical and chemical properties of the materials entering into the product.

Next, standardization was taken up by industrial groups or trade associations and by technical societies.

Later, the scope broadened so that certain features of standardization became national for an entire industry. Thus, in the piping trade there have grown up national standards for the dimensions of pipe, pipe threads, flanges, fittings, bolts, etc., and national specifications for the materials of which they are made. Imagine what confusion the absence of such standards would bring now to the manufacturers and users of these articles.

Pipe Thread Standardization First

That the need for some standardization in piping practice was felt at least a century ago was manifest in the early work of Robert Briggs, whose name is still associated with the Briggs standard pipe thread. Some time between the years 1830 and 1834, a set of pipe thread gauges were made in England under his supervision. Evidently he held a life time interest in this field, since a paper which he wrote on the standardization of pipe threads was presented before the Institution of Civil Engineers of Great Britain in 1882 after his death.

The Briggs standard used in this country was based on the detailed dimensions and formulas given in this paper. While, in a general way, all American manufacturers were threading pipe practically alike in the early eighties, it was not until 1886 that the pipe manufacturers and the American Society of Mechanical Engineers had a joint meeting at which it was decided to work absolutely to the dimensions given by Robert Briggs in the paper mentioned above. At this time master gauges were made to the figures given by Briggs, which standardized the thread on pipe, both as to diameter and length, threads per inch, etc., but neglected to state the exact diameter the fitting having the internal thread should be made to receive the pipe. This was corrected at a later meeting between manufacturers and the A. S. M. E.

One of the first projects undertaken by the American Engineering Standards Committee (now the American Standards Association) was the establishment of an American Standard for Pipe Thread issued in 1919 under the serial No. 3-1919. This standard contains an explanatory note reading as follows: "The above formulas are not expressed in the same terms as the formula originally established by Robert Briggs, because they are used to determine pitch diameters, whereas the Briggs formula determined the outside diameter of the thread. However, both forms give identical results." It is a fine tribute to Robert Briggs that his work has stood the test of time so well.

Flange Drilling Templates Followed

Appreciation of the necessity for standardization of flange drilling templates followed soon after the adoption of a national standard for pipe thread. In 1894, the A. S. M. E., after conferences with the National Association of Steam and Hot Water Fitters (now known as the Heating and Piping Contractors National Association), adopted a standard flange template which became known as the "A. S. M. E. Standard." This standard was suitable for the comparatively low steam pressures then existent, and was the beginning of the present 125-lb. Cast Iron Flange Standard. In 1901, the "Manufacturers' Standard" for pressures up to 250-lb. came into existence as the forerunner of the present 250-lb. Cast Iron Flange Standard. These early standards were confined to drilling templates and flange thicknesses and made no attempt to establish dimensions or wall thicknesses of fittings, or to specify the chemical or physical properties of material.

Cast Iron Flanges and Flanged Fittings

Then, about 1910, a group of manufacturers formed a trade association called the Committee of Manufacturers on Standardization of Fittings and Valves (now known as the Manufacturers' Standardization Society of the Valve and Fittings Industry) and began the work of designing a complete dimensional

NOTE[1]: From title page of A. E. S. C. Year Book for 1928.

standard for cast iron flanges and flanged fittings, including flange dimensions, center to face dimensions and wall thickness. This work was completed and published in 1912. At the same time a special A. S. M. E. committee on flanges, working with the National Association of Steam and Hot Water Fitters, formulated a Schedule of Standard Weight and Extra Heavy Flanges and Flanged Fittings which also was published in 1912.

During the years 1912 to 1914, a joint conference committee, composed of representatives of the Committee of Manufacturers and the A. S. M. E., formulated a group of compromise standard dimensions of cast iron flanges and flanged fittings for use under working steam pressure of 125- and 250-lb. gauge. These standards were based on the 1912 U. S. standard and the manufacturers' standard adopted that year, and were adopted as an American standard in 1914.

SABIN CROCKER

Steel Flange Standards

As steam pressures and temperatures continued to increase, the need for a series of steel flange standards became apparent and an A. S. M. E. committee on the Standardization of Flanges and Pipe Fittings included such a recommendation in its report to the Society at the annual meeting in 1918. This report contained detailed information regarding a cast iron standard proposed by the committee for 50-lb. W. S. P. and semi-steel and cast steel standards for 800-, 1,200- and 3,000-lb. hydraulic pressures.

In this report appeared the following statements regarding the need of steel standards for steam: "Your committee deems it inadvisable at this time (1918) to outline or recommend a standard for 600-lb. steam pressure with superheat, partly because there is no present demand for fittings for this pressure, and because your committee feels that it should be guided somewhat by experience in the field with the pressures and temperatures now in use, namely 300-lb. pressure and 250 to 275 deg. fahr. superheat. Your committee, however, is ready to advise that for 400-lb. steam pressure, and not exceeding 250 degree superheat, the 800-lb. hydraulic American standard in steel is adequate." It is worth mention that these 800-lb. and 1,200-lb. hydraulic American standards in steel later became the basis of the 600-lb. and 900-lb. W. S. P. American steel flange standards.

Organization of American Standards Association

At the time of the organization of the American Engineering Standards Committee (now the American Standards Association) there were hundreds of organizations publishing standards for all kinds of commodities. Most of these standards were formulated without systematic method of co-operation or exchange of information between the organizations concerned, especially between producers and consumers. The A. E. S. C. had its beginning on January 17, 1919, at a meeting of a special committee appointed jointly by the four founder engineering societies and the American Society for Testing Materials, for the formulation of some method of co-operation to prevent duplication in standardization work and the promulgation of conflicting standards. The representation was later broadened to include U. S. governmental departments, and trade associations of both manufacturers and users of the articles.

How A. S. A. Functions

In developing a standardization project, the A. S. A. usually functions through a sectional committee which is assigned some specific task, and which is made up of representatives from the various technical societies and industries, both manufacturing and consuming, which are concerned. Sponsor bodies are designated to be responsible for each project, who select suitable representatives on the sectional committee and generally further the obtaining of a real national consensus. Incidentally, the sponsors contribute to the clerical expense and publication.

Typical sponsor bodies for piping projects are the American Gas Association, the A. S. M. E., the A. S. T. M., the American Water Works Association, the Heating and Piping Contractors National Association, the Manufacturers' Standardization Society of the Valve and Fittings Industry, etc. Two or more of these bodies usually sponsor each project which concerns piping. Progress in standardization has been greatly advanced since full co-operation between producers, consumers, technical societies and governmental agencies has been attained in a national organization operating through the A. S. A.

A. S. A. Piping Standards Already Published

During the ten years in which A. S. A. work has been actively under way, a considerable number of piping standards have been completed and published. Following is a list of tentative or final American standards, with a brief description of each. These standards can be purchased at cost from the American Standards Association, 29 west Thirty-ninth street, New York City. In addition to the W. S. P. (working steam pressure) ratings given, most of the standards so designated have other pressure ratings for non-shock hydraulic service. It is likely that additional ratings for air, gas, oil and other fluids will be established also.

Pipe Thread, Serial No. B2-1919. Dimensions of the elements of the American (Briggs) standard taper and straight pipe thread, plumbers' threads, threads for rigid electrical conduit and threads for thin tubes; formulas for calculating the dimensions of the threads; gauge and working tolerances; methods of gauging the threads.

Screw Threads for Fire Hose Couplings, Serial No.

B26-1925. Threaded parts of fire hose couplings, hydrant outlets, stand pipe connections, Siamese connections, and all other special fittings on fire lines where fittings of 2½, 3, 3½, and 4½ inches nominal inside diameter are used.

Cast Iron Screwed Fittings for Maximum W. S. P. of 125- and 250-lb., Serial No. B16d-1927. Overall dimensions, metal thickness, beading, threading, marking.

Malleable Iron Screwed Fittings for Maximum W. S. P. of 150-lb., Serial No. B16c-1927. Overall dimensions, metal thickness, beading, threading, marking.

Cast Iron Pipe Flanges and Flanged Fittings for Maximum W. S. P. of 125-lb., Serial No. B16a-1928. Overall dimensions, metal thicknesses in flange and body, drilling template, bolting, facing, marking, weights, material requirements.

Cast Iron Pipe Flanges and Flanged Fittings for Maximum W. S. P. of 250-lb., Serial No. B16b-1928. Overall dimensions, metal thicknesses in flange and body, drilling template, bolting, facing, marking, weights, material requirements.

Steel Pipe Flanges and Flanged Fittings for Maximum W. S. P. of 250-, 400-, 600-, 900- and 1,350-lb. at a temperature of 750 degrees F., Serial No. B16e-1927. Overall dimensions, including those of valves, metal thicknesses in flange and body, drilling template, bolting, facings, marking, test pressures, material requirements and an appendix giving appropriate pipe thicknesses.

A. S. A. Standards in Preparation

The following piping standardization projects are now under way. Some have already been published in tentative form for comment.

Screw Threads for Hose Couplings (Other Than Fire Hose Couplings). Nominal values and manufacturing limits for the dimensions of screw threads for small hose couplings, ranging from ½-inch to 2-inch nominal size, and for hose couplings, other than fire hose couplings, over 2-inch nominal size.

Dimensions and Material of Wrought Iron and Wrought Steel Pipe and Tubing. Design, dimensions and material of welded wrought iron pipe, of welded, riveted and seamless steel pipe, and of boiler tubing, including pipe and tubing for high temperatures and pressures.

Cast Iron Pipe Flanges and Flanged Fittings for Maximum W. S. P. of 25-lb. Overall dimensions, metal thicknesses in flange and body, drilling template, bolting, facing, marking, material requirements, weights.

Cast Iron Pipe Flanges and Flanged Fittings for Maximum Working Hydraulic Pressure (Non-shock) of 800-lb. Overall dimensions, metal thicknesses in flange and body, drilling template, bolting, facing, marking, material requirements.

Steel Flanges and Flanged Fittings for Maximum W. S. P. of 150-lb. Supplementary to steel flange standards for other pressure ratings already published.

Steel Companion Flanges for Maximum W. S. P. of 150-, 250-, 400-, 600- and 900-lb. Supplementary to other steel flange standards. Gives height and diameter of hubs for Van Stone and screwed companion flanges proportioned for proper strength ratio.

Cast Iron Long Turn Sprinkler Fittings (Screwed and Flanged) for Maximum Working Hydraulic Pressures of 150- and 250-lb. Overall dimensions, metal thicknesses in flange and body, drilling template, bolting, facing, marking, material requirements.

Cast Iron Ammonia Fittings (Screwed and Flanged).

Face to Face Dimensions of Cast Iron Flanged Valves for 125- and 250-lb. W. S. P.

Cast Iron Pipe and Special Castings. Material, dimensions, pressure rating, methods of manufacture, elimination of unnecessary sizes and varieties, types of joint.

Plumbing Equipment. Materials, uniformity of roughing-in dimensions, efficiency of operation and other performance specifications.

Code for Pressure Piping. Safety code for the design, manufacture and erection of power piping; hydraulic piping; gas and air piping; refrigerating piping; oil piping; covering dimensional standards, material requirements and fabrication details. Preliminary drafts of the sections dealing with (a) gas and air piping and (b) oil piping have been distributed lately in printer's proof form for criticism and comment. Other sections will follow shortly.

Scheme for the Identification of Piping Systems. Identification of piping systems in industrial and power plants, which are not buried in the ground, with special reference to personal hazards in times of accident at a plant.

Rating of Pipe Fittings. The activities of this subcommittee cover all the standards and proposed standards so far prepared by the sectional committee on pipe flanges and fittings. Its immediate task is a thorough study of ratings for the tentative American standard for steel pipe flanges and fittings (B16e-1927).

Marking of Pipe Fittings. This subcommittee will study the problem of marking pipe fittings to permit identifying their ratings as American standards in addition to providing those markings regularly employed by manufacturers.

Materials Specifications

The A. S. T. M. has co-operated actively in the preparation of the above piping standards by drafting material specifications to supplement the dimensional standards of the A. S. A. In a number of cases there existed A. S. T. M. specifications suitable for the application; in other instances, new specifications had to be drafted.

Perhaps the most important feature of this work was the preparation of material specifications suiting the needs of the A. S. A. Steel Flange Standards. At the request of the A. S. A. Sectional Committee On Pipe Flanges and Fittings, the A. S. T. M. created a new subcommittee, known as Subcommittee XXII of Committee AI, to which was assigned the task of drafting specifications for alloy steel bolts, and steel castings, forgings and pipe suitable for service at

750 deg. fahr. To this committee were appointed a number of experts in these lines, with the membership properly balanced between producers and users of such material, and containing several representative men from the consulting engineering field. Rapid progress was made with these specifications so that it was possible to publish them concurrently with the dimensional standards.

Following is a list of A. S. T. M. specifications for piping materials including those referred to above for service at temperatures up to 750 degree F.

A. S. T. M. Specifications for Piping Materials[1]

Alloy Steel Bolting Material for High Temperature Service, Serial Designation A96-27.

Carbon Steel Castings for Valves, Flanges and Fittings for High Temperature Service, Serial Designation A95-28T.

Forged or Rolled Steel Pipe Flanges for High Temperature Service, Serial Designation A105-27T.

Lap-Welded and Seamless Steel Pipe for High Temperature Service, Serial Designation A106-28T.

Welded and Seamless Steel Pipe, Serial Designation A53-27.

Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Ordinary Uses, Serial Designation A120-28T.

Welded Wrought Iron Pipe, Serial Designation A72-27.

Cast Iron Pipe and Special Castings, Serial Designation A44-04.

Cast Iron Soil Pipe and Fittings, Serial Designation A74-18.

Copper Pipe, Standard Sizes, Serial Designation B42-24.

Brass Pipe, Standard Sizes, Serial Designation B43-24.

Grey Cast Iron and High Strength Grey Cast Iron for Valve Bodies, Pipe Flanges and Fittings, no serial designation assigned as yet.

Standards of Particular Industries

In addition to the above dimensional standards and material specifications for piping which are truly national in scope, there are many other standards prepared by technical societies and industries for more limited application. Among the more important of these are the piping standards of the U. S. Navy, the Steamboat Inspection Service, and other governmental departments, the American Petroleum Institute, the American Gas Association and the American Water Works Association, etc. Most of these groups are already taking an active part in national standardization work through the A. S. A. and the A. S. T. M., and it is to be hoped that the need for independent standards will become less and less as the national program progresses. In the manufacture of steel pipe alone this will effect substantial economies through the elimination of unnecessary sizes and thicknesses, with an attendant saving in cost of dies and items stocked.

NOTE[1]: Tentative Specifications have the letter T suffixed to the serial designation; specifications approved as standard do not.

Obnoxious Fumes and Their Elimination

By H. L. Kauffman

THE harmful effects of inadequate ventilation in any building in which persons must spend considerable time are commonly known. One's vitality is lowered; resistance to disease is decreased; and fatigue comes more quickly. To these conditions, in many plants utilizing chemical, electro-chemical or metallurgical processes, must be added the actual danger to life itself by the employes' continually inhaling obnoxious or poisonous fumes resulting from the particular process in use.

Aside from humanitarian considerations, working conditions that impair the health of employes are an

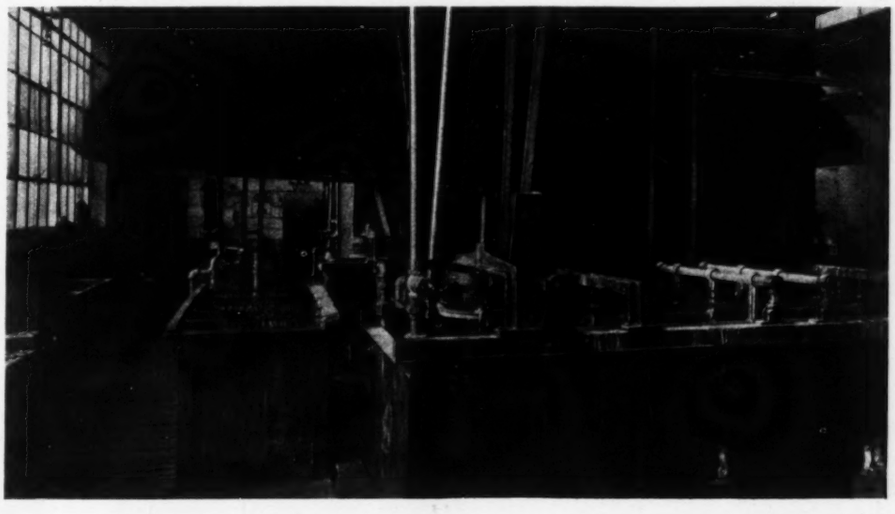


FIG. 1.—EXHAUST HOODS FOR FUMES FROM ELECTRO-GALVANIZING APPARATUS

FIG. 2.—FUME EXHAUST SYSTEM FOR WELDING MACHINES

expense to a plant and modern practice demands that adequate ventilation be provided; otherwise, efficient operation is impossible. The views shown indicate how some companies have solved the "obnoxious-fume" problem in their plants.

Fumes from Electro-Galvanizing

Fig. 1 shows the exhaust hoods installed in another plant for removing the dangerous vapors of hydrocyanic and hydrochloric acid, mixed with steam containing entrained caustic soda, which result from the electro-galvanizing process. The hoods shown in the illustration are connected with simple roof ventilators of the ejector-nozzle type. Because of the corrosive nature of the gases exhausted, both the ventilators and the hoods are painted every two months with a good grade of acid-resisting paint. No power fan is used with this type of ventilating equipment—consequently, there is no power consumption. By means of the installation shown, the employes are enabled to work in comfort and in safety, and valuable electrical apparatus is protected.

Smudge and Smoke from Welders

Fig. 2 shows how the oily smudge and smoke given off by automatic welders (incidentally, on cold or moist days the atmosphere formerly was particularly heavy with smoke) are removed at the point of origin in the chain-welding department of the same plant. It is to be noted that the smoke is carried out of the building by means of simple exhaust hoods over each machine, connected with carefully designed ducts. The two slow-speed exhaust fans that keep the air in motion consume only 8 h.p.

Exhausting Fumes from Pickling Vats

Fig. 3 shows the equipment that was installed in a plant for exhausting fumes from pickling vats. Here, the fumes are ejected through wooden hoods by proper application of the venturi-nozzle principle. The arrangement is one that is equally applicable for use in a vast number of plants where the manufacturing procedure is such as to result in a similar fume problem.

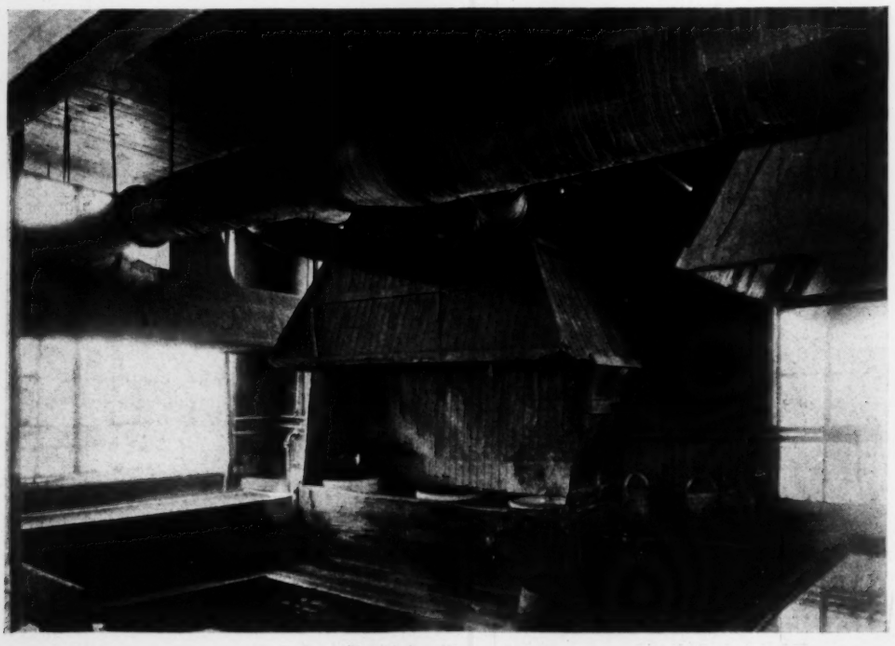


FIG. 3.—EXHAUSTING FUMES FROM PICKLING VATS

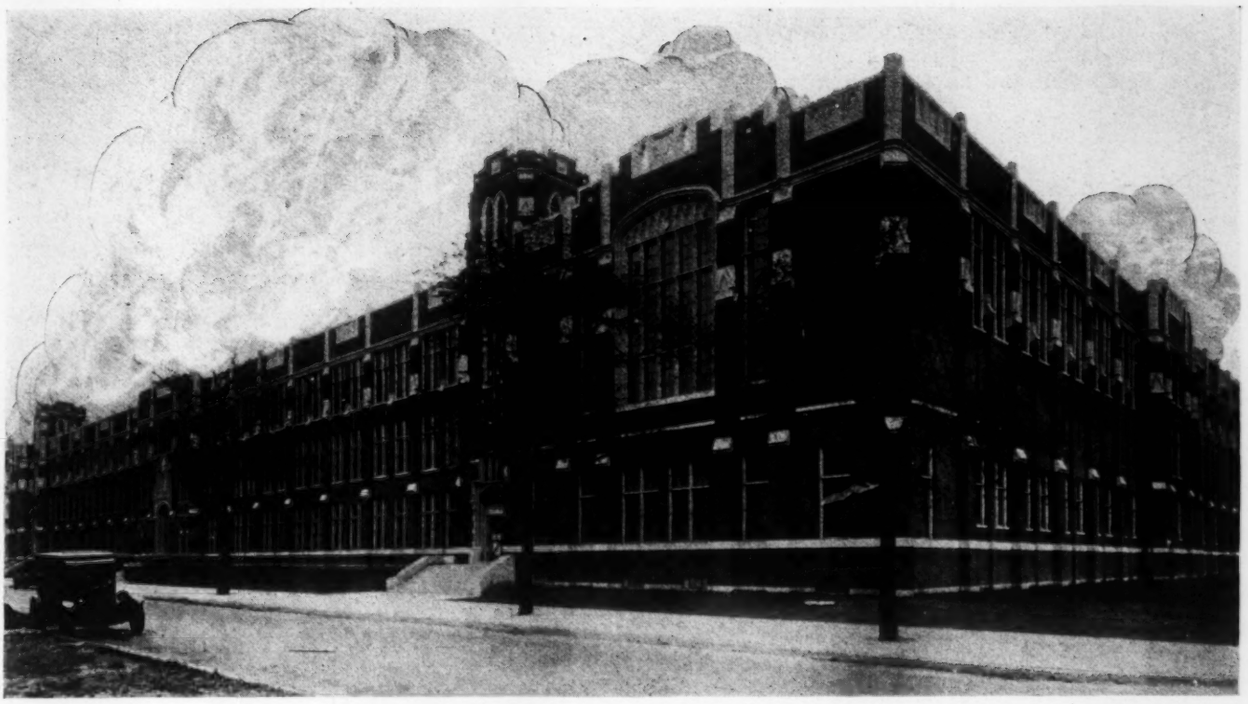


FIG. 1.—THE HUGH MANLEY, JR., HIGH SCHOOL, CHICAGO

Heating and Air Conditioning in a Junior High School

By John Howatt,

Chief Engineer, Chicago Board of Education

THE BUSINESS of education has become the most important business of this nation; the free public schools are at our very foundation and ever since the beginning of our history these schools have been known as the one thing typically and distinctively American; they are the real seat of democracy and the melting pot for all races and creeds. The extraordinary development of this country has been due as much to the influence of its schools as to its rich natural resources. Sections of this country rich in natural resources but poor in educational facilities have not kept pace with other sections where the schools have been closer to the hearts of the people.

However, the citizens of this land are in the main progressive and ambitious, ambitious for themselves and for their children, they want more of the better things of life, a brighter outlook, a broader opportunity for the future and they believe their children will stand a better chance to gain these things through education.

From year to year, therefore, it has been necessary to increase our schools in the scope of their work and in the size and number of the buildings until today the modern school buildings are being provided with equipment and facilities far beyond what was considered necessary even a few years ago, in order to meet the demands of the public.

Not only has the school population increased more rapidly than has the population of the nation, but the number of courses of study and the equipment provided for them has had to be increased. The total public school enrollment in Chicago today is 587,700. The enrollment five years ago was 502,000. Add to this, the 159,600 attending parochial and private schools and the thousands attending the universities and colleges in Chicago and it is seen what a vast army is "going to school."

New Type of School

Within the past five years a new class of school has been introduced into Chicago, the junior high school, taking pupils corresponding to the seventh, eighth and ninth grades. The introduction of this third class of school made it necessary for the board of education to design and construct a new type of building intermediate between an elementary or grade school and a high school. As it has worked out,

however, the junior high school buildings in Chicago are more nearly comparable to the senior high schools in size, equipment and facilities than to the elementary school.

The latest junior high school to be dedicated in Chicago is the Hugh Manley Jr. High School, located at Polk street and Sacramento boulevard. This is a school structure covering an entire city block, and three stories in height, built of steel, concrete, and brick, trimmed in terra cotta and built at a cost of $2,300,000.

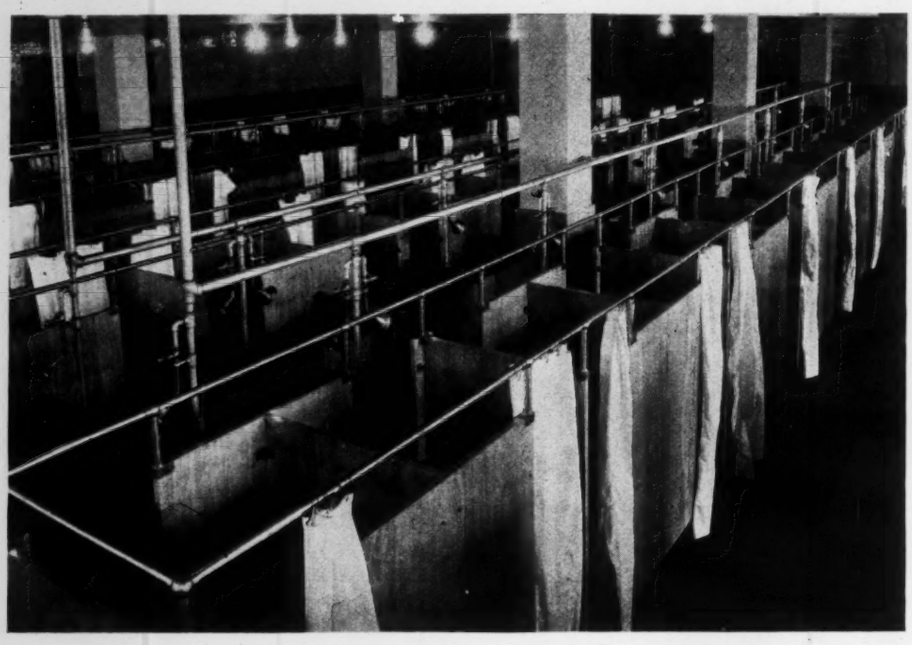


FIG. 2.—VIEW SHOWING MARBLE SHOWER STALLS FOR GIRLS

The engineers in the Chicago public school system have a special pride in this building because it is named in honor of one of their members, Hugh Manley, who died as a result of an injury sustained in the performance of his duty. He was an engineer in charge of a plant in one of the public school buildings at a time when an accident in the boiler room caused boiling water under 100 pounds steam pressure to flood the room; he went through that scalding steam and water to close a valve, risking his life in order to insure the safety of others in the school building. The engineers are pleased to know that courage and devotion to duty are recognized and appreciated in whatever rank they may be found.

The Hugh Manley Jr. High School is a building containing classrooms, offices, library, civics room, lunchroom, two gymnasiums, one for boys and one for girls, with separate locker and shower rooms for each, natatorium, assembly hall and usual spaces and rooms for equipment and auxiliaries.

Hot Blast and Direct Radiator System

As is the custom in school buildings in Chicago, the heating and ventilation are combined in the hot blast and direct radiator system. The indirect or blast radiation consists of 27,000 sq. ft. of cast iron heating surface divided into eight units or heating chambers; 211,000 cu. ft. of air per minute is brought into the building from above the roof line to provide ventilation and is forced through tempering stacks to bring it to a temperature of 65 deg. fahr., delivered into the sub-corridors for distribution and then through small banks of three indirect radiators and directly up through vertical ducts to the classrooms where it is delivered in constant volume and velocity at a varying temperature such as will maintain the classroom temperature between 68 deg. and 70 deg. At the bottom of each vertical duct is the usual mixing damper controlled by a thermostat in the room so the room will receive tempered or heated air or both.

30 C. F. M. for Each Desk

When the ventilation contract is completed a test of the air delivered through every register is measured by calibrated anemometers. During the test, an adjustable volume damper in each stack is set so 30 cu. ft. of air per minute will be delivered into the room for each desk. It has been found that when mixing dampers throw over to take all tempered air a greater volume of air than desired is discharged into the room due to the reduction in resistance when the heating radiators are by-passed. This has been corrected by providing a second adjustable damper in the by-pass duct set by test to artificially introduce a resistance equal to the resistance through the radiators. It may be said that there has been no complaint of drafts in any room in this building, indicating a satisfactory air distribution and air movement.

For several years it has been the practice to eliminate, as far as possible, all runs of horizontal duct in designing ventilating systems for the Chicago public schools. The stale odors sometimes complained of in mechanically ventilated rooms frequently result from dust and dirt settled in the long horizontal portions of the air supply system. Very little dust will cling to smooth vertical surfaces. The sub-corridors on the tempered air distribution in the

Hugh Manley Jr. High School are 12 ft. wide and 8 in. high, finished in smooth cement and provided with hose connections so they can be washed out. A system like this should deliver air just as wholesome and fresh after ten years of service as it does when first put into operation.

Supply System

The air for general ventilation is furnished by eight multivane blowers taking air from the supply shafts in different parts of the building and delivering it at 1¼-in. static pressure. All of the air used in ventilation work is passed through air washers designed for an air velocity of 450 ft. per minute through the washer.

The air supply for the assembly hall is on the upward movement principle. The space under the hall is a plenum chamber, the air entering the main hall and balcony through 303 floor air heads and leaving through ceiling registers into an attic vent chamber. Both the upward and downward air movement principles of ventilating halls and gymnasiums are practiced in Chicago, dependent upon the physical characteristics of the halls.

The blowers for the assembly hall, lunchroom and boys' and girls' gymnasiums are driven by 220-volt, 3-phase 40-deg. type electric motors. The blowers for general classroom ventilation are driven by center crank enclosed throttling type steam engines. The blowers for the special rooms are motor driven because these spaces will be used at times when steam is not required for heating but ventilation will be essential. The blowers for classroom ventilation are engine driven in order to reduce the operating costs, the exhaust steam from the engines being piped into the low pressure heating mains after passing through separators. It has been our experience with motor driven ventilation blowers in schools that the cost of electrical energy for driving the blowers exceeds the cost of the energy for the entire lighting load.

Exhaust System

In general, air is exhausted by the natural exhaust single duct system venting to the roof. There are four electric motor driven exhaust fans located in the attic, however, one for the natatorium and shower rooms, one for the lunchroom and kitchen and two for pupils' toilet rooms. These systems are all entirely separate from the general ventilation system.

The duct work for conveying air, with the exception of sub-corridors for tempered air, is constructed of galvanized sheets. First grade prime sheets are used throughout, the vertical ducts being 26-gauge and the attic ducts 24-gauge with roof ventilators of 20-gauge copper bearing plates. The vent duct from the storage battery room is of 20-gauge copper bearing plates extending through the roof and coated inside with acid resisting paint.

A special heating and ventilating unit was designed for drying the hair of pupils using the swimming pool. It consists of a small motor-driven blower capable of delivering 1,800 cu. ft. of air per minute at 1½-in. static pressure through a steam header into an air duct of 20-gauge galvanized iron built with soldered joints. From this air duct are taken flexible outlets consisting of 2-ply wire reinforced rubber covered 2½-in. vacuum cleaner hose, fastened at the upper end to collars on the duct and terminating at the lower end in aluminum angular discharge nozzles. The heating unit consists of a brass tubular heater 29 in. wide by 24 in. long, two rows deep, containing 70 linear feet of tubing.

Recirculation

Recirculation of air for classrooms and general ventilation is made possible by a cross connection from the attic vent ducts to the outside air intake shafts, supplying classroom blowers. An arrangement of pneumatically operated dampers is provided so the air from the classroom vents may be discharged directly out of doors or into the air supply to the blowers, at will. This is of great value for heating the building in the morning before occupancy even if it cannot be used during the period of class sessions. General recirculation of air for ventilation purposes is not permitted by the Chicago building ordinances under ruling of the health department that fresh air means outdoor air, but all of the public school buildings designed in Chicago in the past three years have been provided with some means of recirculation similar to that described for use when the building is not occupied

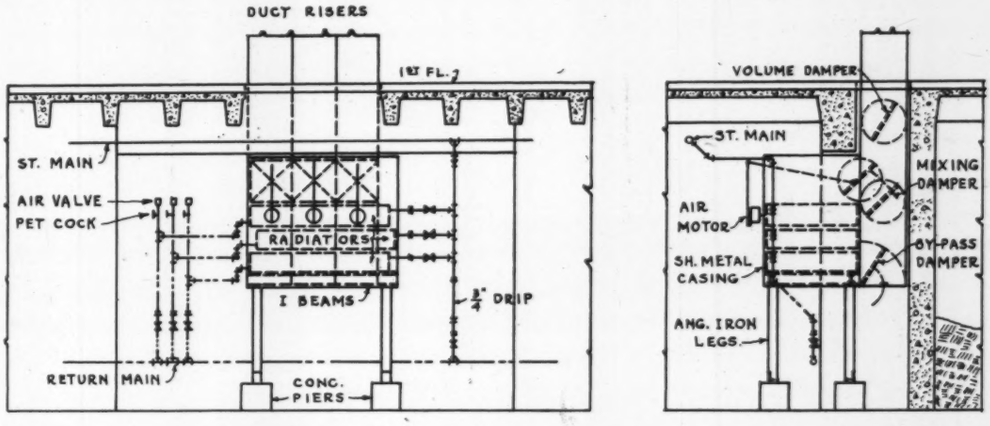


FIG. 3.—ELEVATION OF RADIATOR STACKS IN TEMPERED AIR CORRIDOR

and for possible use if the present ordinances are amended to permit recirculated air for general ventilation purposes.

Direct Steam Radiation

The heating of this building by this air supply system is supplemented by 5,300 sq. ft. of direct steam radiation of the tubular or wall types, located in offices, corridors, toilet rooms, library, civics rooms, natatorium and other special rooms. The direct radiators in vestibules and natatorium are in a recess in the wall construction and covered with cast grill work. The wall back of these radiators is lined back, sides and top with 24-gauge galvanized iron, curved outward at the top, and backed with ½-in. thick asbestos. The radiators in the office, civics room and library are ornamentally enclosed and their appearance has been considered more than has their heating effectiveness.

Temperature Regulation

The temperatures throughout the entire building are maintained within 2 deg. of that desired by an automatic system of temperature control. In order that the chief engineer of the plant may more readily check up on room temperatures in any part of the building, an automatic temperature indicating system is provided. By pushing the button corresponding to any room on the panel in his office, the pointer indicates the exact temperature in that room at that instant. In that way the engineer is able to check up the temperatures in the different rooms in any part of this large building in less than two minutes. Automatic humidity control is provided to maintain the relative humidity at 40 per cent, outside weather conditions permitting.

Boiler Rating Under Maximum Load

Calculations for heat requirements in Chicago public school buildings are based upon an outdoor temperature of minus 10 deg. and an inside temperature of 70 deg., using standard formula for heat losses through walls, roof, etc. These preliminary calculations for the Hugh Manley Jr. High School indicated that in order to provide heating and ventilation under the conditions named, it would be necessary to condense 45,500 lb. of steam per hour, equivalent to 1,500 h.p. It has been our experience in school plant design that the most economical boiler installation results when the boiler rating is considerably less than the maximum load requirements. It is only for a few days each season that a maximum load as calculated has to be carried and it is much more efficient to overload boilers and drive them harder for these few days, possibly at an inefficient load point, and have them operated at a lower but more efficient load point for the greater part of the time. It has been our practice to calculate boilers in a plant like the Hugh Manley Jr. High School on a 150-per cent load basis during severe weather. Consequently, 900 h.p. was provided consisting of three 300 h.p., vertically baffled, single cross drum water tube boilers designed for 160-lb. working steam pressure in accordance with the A. S. M. E. code. Three boilers are used to provide flexibility to heat during varying weather conditions. The three boiler unit is used in Chicago public schools in the power plant more than any other unit.

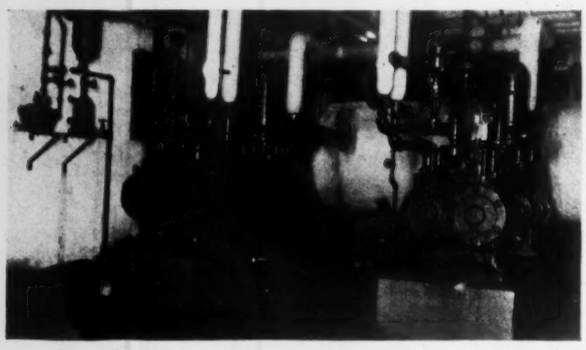


Fig. 4.—Boiler Feed Pump and Receiving Tank

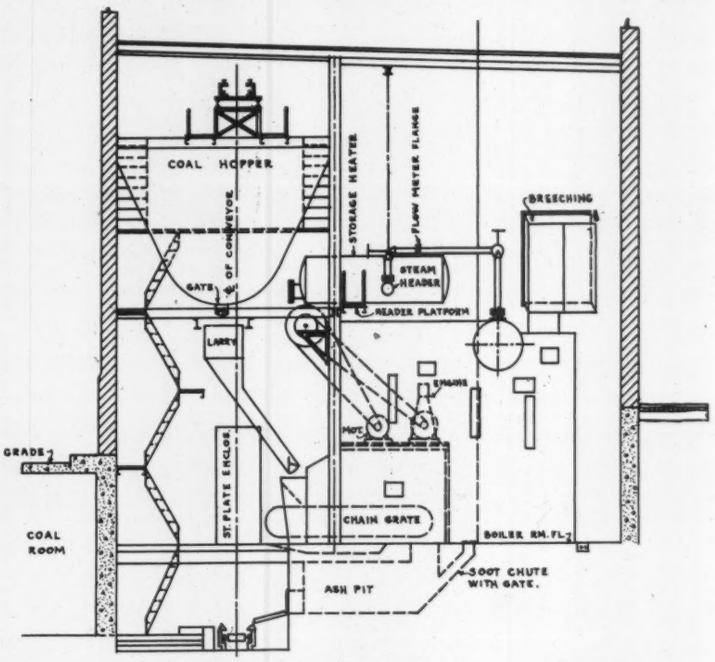


Fig. 5.—Sectional Elevation Through Boiler Room

The selection of type of stoker is dependent upon the size of the plant and the structural characteristics of the boiler house. For units of 300 h.p. or larger, it is our general practice to install chain grates, which was the selection in this instance. The chain grates are of standard design, natural draft, driven by one enclosed vertical type steam engine, driving an operating shaft through pulleys and clutches. A separate electric motor drive is provided for use in emergency and in starting up in the morning when there is no steam pressure on the header.

Everyone who operates a coal-burning plant at overload, experiences trouble and expense from failure of the refractory material in the furnace side walls. Various devices are tried to prolong the life of the furnace brick work, the most common being

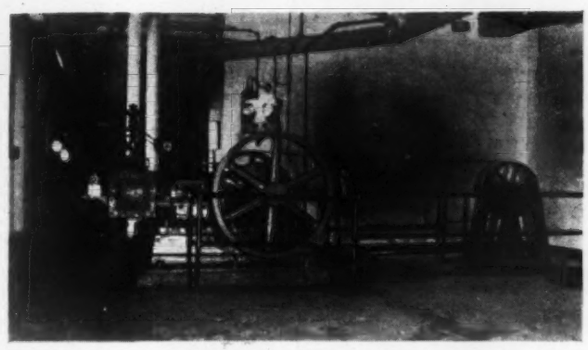


FIG. 6.—ENGINE DRIVE ON BLOWER

air cooling. The furnace side walls in the Hugh Manley Jr. High School are lined with air cooled furnace blocks from the grates up to a line 2 ft. above the grate line. The outside of the furnace walls and the outside of the boiler setting are covered with two coats of furnace seal to prevent air infiltration.

An auxiliary needed on every boiler, especially those designed to burn Illinois coal, is an effective and dependable and easily operated soot blower. Everyone realizes the great fuel loss that is sustained in operating soot loaded boilers; nothing can give more trouble or cause more loss in the boiler plant than the soot problem. These walls are equipped with rotary, side wall type, steam, soot blowers.

Auxiliaries Should Pay Way

It is very easy for the designer of a plant to succumb to the wiles and plausible arguments of a specialty salesman to the extent of specifying and having installed more devices and equipment than the plant can afford to carry. There is no advantage in providing auxiliaries intended to effect plant economies, for example, if those economies will not return the original cost and maintenance of the extra equipment throughout its life, nor is there any reason for installing expensive equipment and appliances which experience has shown will not be used enough by the plant operatives to justify their cost. School plants are operated in this climate only 200 days per year, so an expense in auxiliaries that would be justifiable in a commercial plant operating 365 days per year, might not be justifiable in one running half time.

Special devices, therefore, have been omitted in the Hugh Manley Jr. High School plant design. Every boiler is equipped only with a steam gauge and a steam flow meter or horse power indicator set side by side. It has been found that the horse power indicator is a great help to the engineer and the boiler room crew to indicate which boiler is failing to carry its share of the load and warns them to look out for the cause and apply the remedy. A horse power indicator has been adopted as standard equipment in all of our large Chicago public school plants. The boiler breeching is equipped with a smoke observer by means of which the fireman can have immediate knowledge of the condition of the stack as to smokiness, and as this equipment is placed conveniently it is used as intended. This building is located in a residential section and precautions have been taken to eliminate, as far as possible, the dust,

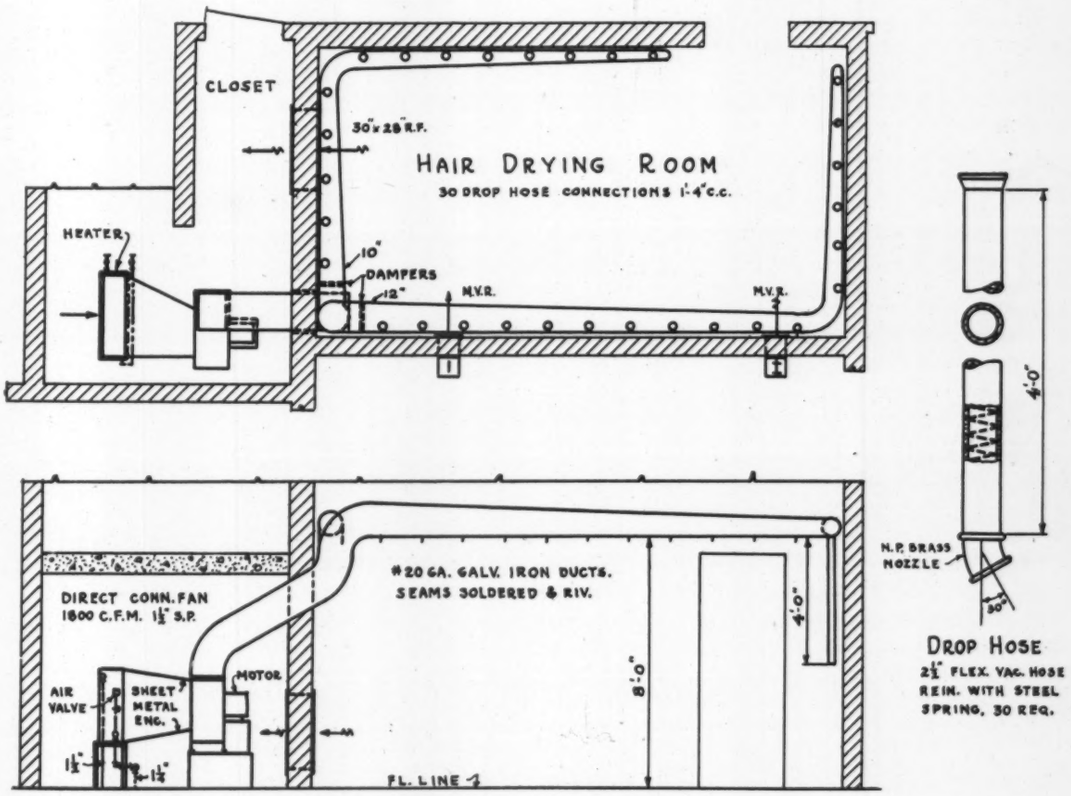


FIG. 7.—PLAN AND ELEVATION OF HAIR-DRYING EQUIPMENT

dirt and ashes often incidental to the operation of a boiler plant.

Steam Distribution

Distribution of steam throughout the building is by a system of high pressure mains to various heating chambers, where the pressure is reduced by pressure regulating valves in one step and set to provide automatically any deficiency in the quantity of the exhaust steam. The water of condensation from the heating stacks and direct radiation is received in seven automatic pump and receiver outfits located in different parts of the basement. These discharge into one main receiving tank 48 in. diameter by 12 ft. long, in the pump room. Two duplicate boiler feed units, each consisting of a duplex bronze fitted outside center packed steam pump 10-in. cylinders by 6-in. water cylinders by 12-in. stroke, take the water from the main receiving tank and discharge it through a straight tube, closed type, feed water heater designed to heat 4,200 gallons of water per hour from 150 deg. to 200 deg. with steam at 5 lb. gauge pressure. The boiler feed pumps, as well as all engines throughout the building are fitted with mechanical lubricators and with a pump regulator set to maintain a boiler feed line pressure 30 lb. in excess of the boiler steam pressure.

Exhaust steam from the pumps is piped through a separator to the feed water heater and to the hot water tank heaters. Back pressure on all pumps and engines is limited by back pressure valves set to release at pressures in excess of 5 lb. gauge.

There is a small tank heating boiler of the fire box type rated at 60 h.p. capacity set alongside of the main power boilers for the production of low pressure steam used in the steam heaters for heating water for general use in the building and for the swimming pool and to provide steam to the laundry and kitchens. It has been found advantageous to provide a small boiler of this type in larger buildings to burn rubbish and for Saturday and summer vacation period service.

A carrier serves the double duty of both a coal and ash conveyor. Coal is delivered by truck and dumped into a below-grade coal room from which it is conveyed into steel coal bunkers supported over the furnace hoppers. A movable larry serves to direct coal from overhead bunkers into the hoppers of any furnace desired. Ashes are conveyed into a concrete ash room over a driveway where they may be dropped directly into a truck and carted away. Handling of coal and ashes is thereby accomplished without creating any nuisance in the neighborhood.

No mention is made in this description of any except heating and ventilating equipment. Other interesting features in this building are a complete automatic inter-communicating telephone system; an automatic fire alarm system with stations at convenient points on each floor; an electric clock system with program bells; an electric air drying machine in each toilet room; radio outlets in every room; a laundry and sterilizer outfit for swimming suits, and a liquid chlorine sterilizer outfit for treating the water in the swimming pool.

The Board of Education feels that in this building it has provided complete facilities and equipment to meet all of the present day demands of the public, without extravagance, and it is hoped that the thousands who will pass through this school will be benefited by the mental and physical training received therein so they will be better able to cope with the problems of life and be proud to say in after years that they were graduated from the Hugh Manley Jr. High School.

Welding as Applied to District Heating

IF ONE may use the words "portable" and "stationary," as applied to the art of welding, the new and the old will be clearly distinguished. A few years ago we carried all our pieces to be welded over to the forge to be heated; now we carry the heat to the place of fabrication. Then, it required physical work to join the semi-fused parts; now, they are fused and puddled.

There are three methods of fusion welding; the oxy-acetylene method, commonly called the gas method; the ordinary electric-arc method (carbon-arc and metallic-arc); and the hydrogen-arc method. The latter is the electric-arc, with tungsten electrode, in an atmosphere of hydrogen.

The oxy-acetylene method and the ordinary electric-arc method each has its own peculiar adaptation and in certain specific lines is preferred; these two, however, may be used interchangeably in most types of plain welds. For cutting and wrecking purposes the gas method is largely used. The hydrogen arc method is preferred for a steel weld more than for a weld in cast iron. It is more expensive than the ordinary arc method, which will necessarily limit its range of usefulness.

In the following varieties of work the district heating man will find both the gas and the electric methods very necessary: cutting metals and wrecking old machines and structures; joining broken steel parts without dissembling; joining cast metal parts, reclaiming imperfect castings, joining pipes and fittings without screw threads and joining sheet metal plates and rolled steel sections without rivets. In fact, one of the most important tools in the plant and in the field is the welding outfit.

These are some remarks by Prof. J. D. Hoffman, director of the department of practical mechanics, Purdue University, Lafayette, Ind., and were presented in a lecture on welding at the third district heating school conducted at that institution May 20-25, 1929.

Welding rods were discussed as regards composition, coating and use; also, types of welds were exhibited by lantern slides.

Following the lecture were demonstrations of the use of gas and electric welding apparatus, a discussion of the action of the torch and the arc and some of the difficulties involved in welding.

X-Rays and X-Ray Inspection in Piping

FIG. 1.—LEAD CABINET IN WHICH X-RAY PICTURES ARE TAKEN. A TEE FITTING FOR A HIGH PRESSURE STEAM LINE SET UP READY FOR WORK

By Herbert R. Isenberger

WHEN Professor Roentgen announced, thirty-four years ago, that he had discovered a light ray which would penetrate solid objects and that he had made it possible to see through solid sheets of metal, his discovery was regarded as of great interest to scientists, but of little value for everyday practical purposes. Probably it never occurred to him that some day the X-ray would be used in the piping industry and that it would play a part in the production of fittings of more dependable character. However, within the last few years, engineers have been able to make practical use of it for the inspection of castings and forgings.

The Nature of X-Rays

Concerning their nature, X-rays are electromagnetic vibrations in every way similar to those of ordinary, visible light except that the average wave-length is only about 1/6000 as great as that of yellow light. As to their generation, X-rays are emitted whenever matter is bombarded by cathode rays. The essential parts of an X-ray generating apparatus are, therefore, a source of electrons proceeding from a cathode, which is a hot-wire filament in a vacuum tube; a target or anticathode or anode in the path of the cathode-ray stream; and a means of applying a potential difference between the cathode and the target which will accelerate the electrons to the required velocity during passage across the intervening space.

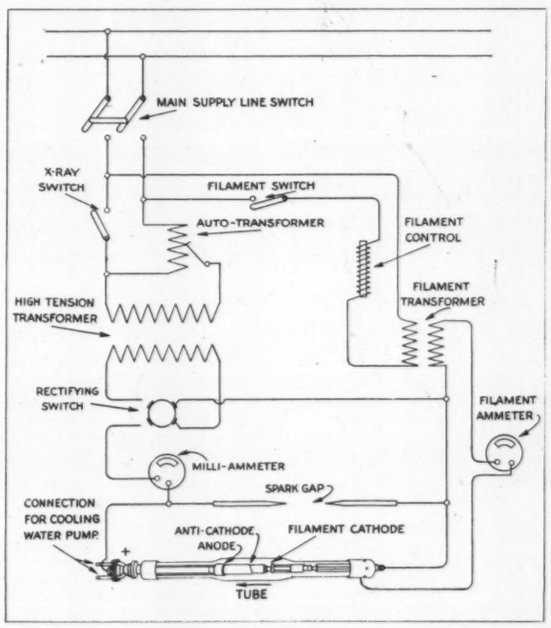


FIG. 2.—A TYPICAL INSTALLATION FOR GENERATING X-RAYS

It is impossible to give a complete description of all

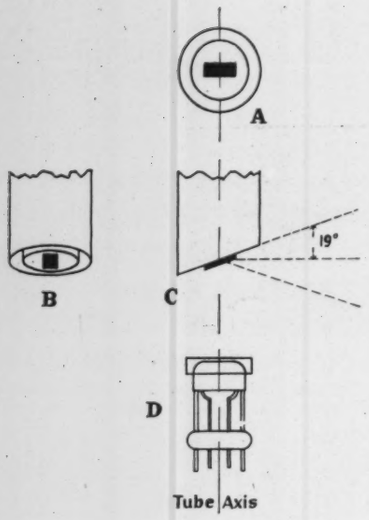


FIG. 3-4-5.—ILLUSTRATING THE FOCUS PRINCIPLE

the properties of X-rays here; they may be found in any physics book. In their application to heating and piping, we are concerned primarily with the properties of differential absorption in matters and the blackening of the photographic plate. There are three methods of investigation, based upon the three qualities characteristic of the short electro-magnetic waves: —their penetrating power, their selective absorption of certain wave-length different for each element, and their diffraction in crystals.

The Apparatus and Tube

A typical installation for generating X-rays is shown in Fig. 2.

The tube shown in this drawing operates on what is known as the line focus principle; the area of the anode, bombarded by the stream of electrons emanating from the cathode, is a line as seen in Fig. 3. In order to reduce this line to virtually a point source of X-rays, the anode surface is inclined at 19 deg. as shown in Fig. 4, *C*. When viewed from the direction of the central ray the line now appears as a spot, see Fig. 5, *B*.

A further important feature of this water-cooled tube is the presence of helium gas in the tube. Owing to the molecular dimensions of the helium atom (the helium atom contains only two electrons) a pure electron discharge occurs at much higher gaseous pressure than would be possible in the presence of air. The greatest practical advantage, however, is the extraordinary freedom from risk of puncture which is characteristic of the helium tube. Furthermore, the tubes offer the most efficient protection against X-rays, as the entire tube is packed in a lead box, absorbing all primary X-radiation with the exception of the useful beam which emerges through a small round glass opening. These factors enable the radiologist and radiographer to produce consistently, without interruption by tube breakdowns, X-ray work of the highest possible quality.

Fig. 6 shows a fluoroscopic arrangement which can be very usefully applied to many problems in the heating and piping industry.

Radiography and Diagnosis

The usual way of recording X-rays is by the "shadow picture," or exograph, registered on a photographic film. As with ordinary photographs, darker regions on the negative or lighter regions on the print mean that more light has passed through the object and that it is more transparent at that point. With this in mind there should be no difficulty in understanding the accompanying illustrations. But before showing more practical applications, we want to see how the radiographic method is applied for examination theoretically.

How Radiography is Applied

The method of examination, which we designate as "radiography," is based on the penetrating power of X-rays. It refers to the testing of raw materials and to the examination of rough, semifinished and finished products of high value such as castings, soldered of welded seams, etc., to discover faults within materials, such as slags, shrinkage, blow holes and the like.

The pieces under investigation are placed between the focus of an X-ray tube and either a photographic film or fluorescent screen. An irregularity in the density of the plate, which is not caused by an exterior treatment, or in the fluorescence of the screen indicates such faults. Fig. 7 shows schematically a radiographic arrangement for photographic X-ray examination.

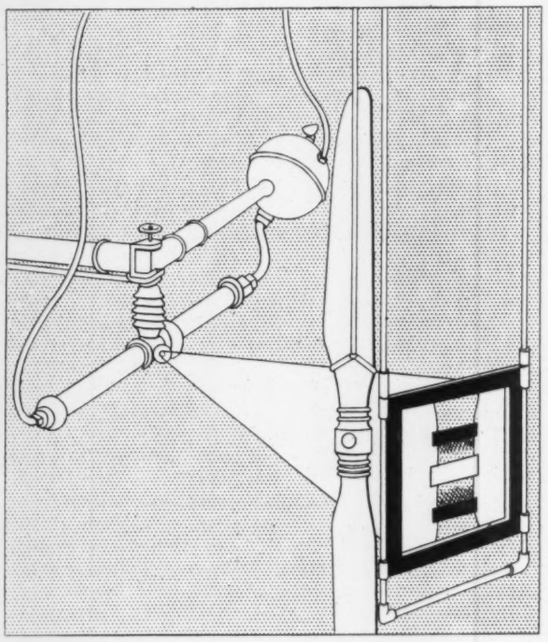


FIG. 6.—FLUOROSCOPIC ARRANGEMENT WHICH CAN BE APPLIED TO MANY PROBLEMS IN PIPING

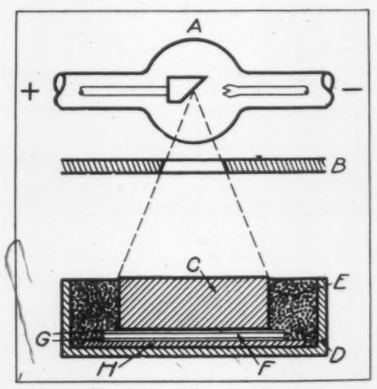


FIG. 7.—RADIOGRAPHIC ARRANGEMENT FOR MATERIAL RADIOSCOPY WITH PHOTOGRAPHIC PLATE. A—X-RAY TUBE, B—DIAPHRAGM OF LEAD, C—MATERIAL FOR RESEARCH, D—LEAD TANK, E—LEAD SHOT AS PROTECTION AGAINST SECONDARY RAYS FROM THE WALLS OR FROM OBJECTS OF THE TESTING-ROOM, F—DUPLITIZED FILM, G—INTENSIFYING SCREENS, H—SHEET BRASS AS PROTECTION AGAINST SELF-RADIATION OF THE LEAD EMITTED BACKWARDS

FIG. 8.—A PORTION OF A LARGE CAST STEEL TEE 3 INCHES IN DIAMETER FOR A HIGH PRESSURE STEAM PLANT. THE JAGGED LIGHT STREAKS INDICATE SHRINKAGE CRACKS WHICH WERE SO NUMEROUS THAT THE CASTING HAD TO BE REJECTED

With larger pieces and increased tensions, the fogging influence of the stray radiation arising in the piece under investigation is highly remarkable. The outlines become soft, the differences in the opacity diminish, owing to the general fog, and the visibility of the contrasts becomes reduced thereby. To some extent this drawback can be overcome by the employment of movable diaphragms, in which case the durations of exposure will have to be lengthened considerably. For the purposes of metal radioscopy, relatively high tensions on the X-ray tube are required, if the limits of a reasonable duration of the exposure are not to be exceeded. Still, we lack apparatus and tubes for sufficiently high tensions and capacity.

Depending upon the distance between the target and photographic plate, a high number of milliamperes must be discharged through the tube in order that there be great penetrating power and adequate intensity of radiation. The distance generally has to be great, in order to obtain sharply defined outlines of the faults by means of large extension of the focus. Small target-distance produces a haziness due to the breadth of the focus which makes it difficult to recognize the minor faults. Therefore, tubes of a great capacity, with a focus in the form of a dash, should preferably be taken, in such a manner that their focus seen from the object seems like a point.

Fluoroscopy Arrangement

Fig. 10 shows an arrangement as made with pieces of a small thickness or of an inferior ordinal number (low absorption coefficient), where the end radiation emitted behind the specimen, is still great enough to stir up a fluorescent screen to an effective fluorescence radiation.

The diminishing strength of the X-rays, while penetrating materials, limits inspection. These limitations of metal radiography are within sight today. Formations as thin as a hair existing in larger pieces very seldom can be discovered. Air bubbles can be discovered only on condition that their thickness in the direction of the beam does not amount to less than about one per cent of the total material thickness at this spot. Extremely fine sponginess in heavy brass castings cannot be recognized on the X-ray picture in many cases.

Continuous Current Kilo-voltage	Thickness of Material Under Investigation			Exposure Time 1/1000 Amp. x Minutes
	Brass and Bronze	Iron and Steel	Aluminum	
95.....	⅜″	1 ″	6¼″	240
115.....	⅝″	1⅛″	8¼″	200
130.....	⅞″	1½″	9½″	200
185.....	1½″	2⅜″	13 ″	160
230.....	2 ″	3⅛″	15¾″	80

FIG. 9.—A—POSITIVE AND B—NEGATIVE OF THE SAME X-RAY PICTURE

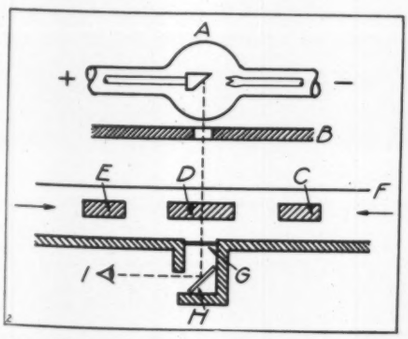


FIG. 10.—RADIOGRAPHIC ARRANGEMENT FOR MATERIAL FLUOROSCOPY WITH FLUORESCENT SCREEN. A—X-RAY TUBE, B—LEAD DIPHRAGM, C-D-E—MATERIAL RESEARCH, F—MOVABLE TABLE FOR THE AUTOMATIC PASSING OF THE MATERIAL UNDER INVESTIGATION BEFORE THE FLUORESCENT SCREEN, H—MIRROR, I—VIEWER

Practical Examination

In practical, routine examination satisfactory details are obtained in radiographic inspection of brass and bronze up to 2-in. thickness, iron and steel up to 3½-in. and aluminum up to 12-in. For inspection on the fluoroscopic screen the limits are:—for brass and bronze about ⅜-in., iron and steel 1-in. and aluminum 4-in. The appearance of the defects is almost the same for the different materials. Straight, smooth shapes are more suitable for examination than complicated ones with different thicknesses, which require skilled technique.

Exposure Times

The above table gives practical exposure times for brass and bronze, iron and steel and aluminum. The tests were made with a duplitized film and two intensifying screens with a focus distance of 16 inches from the film. The last column shows the current in 1/1000 amperes multiplied with the exposure time in minutes.

Examination of Metal Castings

Of great importance are the examinations by X-rays

FIG. 11.—PHOTOGRAPH OF A FRAGMENT OF THE FITTING X-RAYED IN FIG. 8

of metal castings, except lead, which frequently have blow holes or impurities. These photographs are a great help to the metal industry in general and to the heating and piping industry in particular. In the future, up-to-date manufacturers may find it desirable to apply X-ray inspection as a matter of routine. For the investigation of welded or riveted joints on boiler connections and for fluoroscopy of building stones or insulating materials, too, this method is of great value.

An exograph will show whether there are cold shuts or other defects in the casting which are not visible on the surface. The soundness of castings subjected to hydraulic pressure, for example, is extremely important, and the X-ray is the only means by which the interior of the casting may be examined without destroying it or causing any physical or chemical change. Forgings and boiler plate may be similarly inspected for internal defects. Serious waste in the metal working industry often occurs because of internal defects discovered in the work after considerable machining has been done. Claims for damages are sometimes made, because internal defects in parts which were not discovered when building the machine or installation have caused subsequent failure

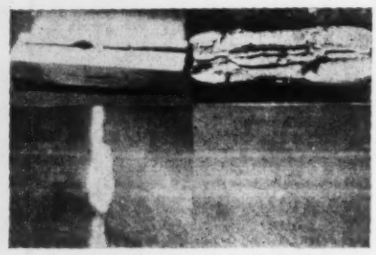


FIG. 13.—FOUR PICTURES OF A PIECE OF ROLLED STEEL.

in service. Quite frequently castings which have stood the high pressure tests, have started to leak after a short time in service because internal cracks developed during the test. Some typical illustrations in this article show these facts.

Practical Applications

In Fig. 9 (a) and (b) we see the positive and negative of the same X-ray picture. Fig. 9 (a) (positive) is a photograph of the picture as it appears on the fluorescent screen, whereas Fig. 9 (b) represents the shadow picture (negative) on the film. These illustrations show an electric welded boiler plate, 1/3-inch thick. Inasmuch as the thicker material absorbs more X-rays than the thinner parts, the weld appears as a lighter region in fluoroscopic inspection and as a darker area on the film. The seam itself is a white line through the center on the positive and a black line on the negative where the X-rays find but little resistance.

Examining High Pressure Fittings

For the examination of heavy castings, radiography with films is exclusively employed. Fig. 8 shows a portion of a large cast-steel tee intended for a high pressure steam plant. The jagged light streaks indicate shrinkage cracks, which were so numerous that the casting was rejected. Not only did this save useless machining cost, but it also averted a serious accident, which would probably have occurred had this casting been put in service. Fig. 11 is a photograph of a fragment taken from this region when the fitting was broken up for visual inspection. Fig. 12 is a portion of a 5-in. ell for the same steam plant, showing a chaplet, a large cavity near it, some sand inclusions, and a series of cavities, one being more than an inch long. This, too, was rejected with corresponding savings. These two exographs were each made at about 200,000 volts, with exposure of less than 30 seconds. The illustrations, of course, present horrible examples, and must not be considered as representative of castings as a whole. In fact, X-ray examination has shown that with proper foundry procedure, castings can be made surprisingly free from defects.

FIG. 12.—PORTION OF 5 IN. ELL SHOWING CHAPLET, SAND INCLUSION AND SERIES OF CAVITIES

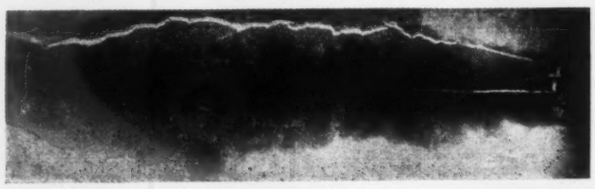


FIG. 14.—WELDED JOINT OF BOILER-PLATE.

X-Ray Inspection of Welded Parts

Fig. 14 shows a welded joint of a boiler-plate (photograph and exograph) whereby the X-ray inspection disclosed a serious crack next to the welded joint. In this connection, it may be of interest to know what can be proved by X-ray inspection of welded parts. The following questions can be answered with an exograph:

Is a weld sound throughout?

Do there exist any inclosures of gases, slags, sand or other impurities?

Was there any undesired absorption of gas?

Is the arc light normal or too large for a certain electric weld and what was the currents' ratio?

Is a weld burned?

How did the binding turn out?

Did any cracks develop within the welded section or the neighboring region and what causes such shrinkage?

Of what influence was the heat treatment?

Are there thinner or thicker spots within the weld caused by improper welding?

Were there any repairs made afterwards, like caulking copper welds and the like?

In this way, not only can the welding process be improved, but also the welders' work can be controlled and bettered.

Furthermore, it interests the welding engineer to know interior defects not visible from the outside, like rolled out shrinkage holes, which otherwise would only appear during tooling or machining, especially by cutting the material. In Fig. 13 we have a piece of rolled steel (flat iron) ¼-in. thick. The lower left hand view shows, besides fine horizontal lines which indicate rolled out shrinkage, loss of material on account of burning and slagage, which was proved in the photograph of the etched section, upper left hand view, where the shrinkage shows up as a dark crack in the profile. There was another exograph taken in another part of the same specimen, as shown in the lower right hand view, which plainly illustrates the same shrinking characteristics. In the upper right hand view, the bending test finally proved that the inner structure of the ma-

X-rays, thought of, as a rule, only as the means by which the physician and surgeon can have any part of the interior of the human body made clear in picture form, have another use in which the engineer should be interested. They have been successfully used to picture the interior of metal castings, such as pipe fittings, and thus enable the engineer to determine whether or not some flaw exists which will make the use of that fitting dangerous or short-lived. This is an interesting and practical article — interesting in the possibilities it suggests for better materials and practical in its clear explanation of how the X-ray can be applied in this field.

FIG. 16.—A BRASS BAR ABOUT 1-IN. THICK SHOWING SLIGHT POROSITY TOWARD THE EDGE

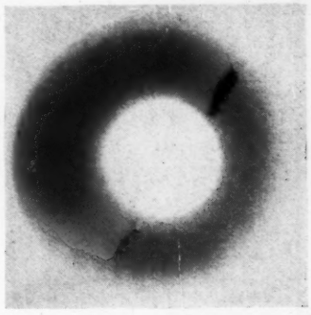


FIG. 17.—EXTRUDED BRONZE BUSHING SHOWING LITTLE LACK OF HOMOGENEITY

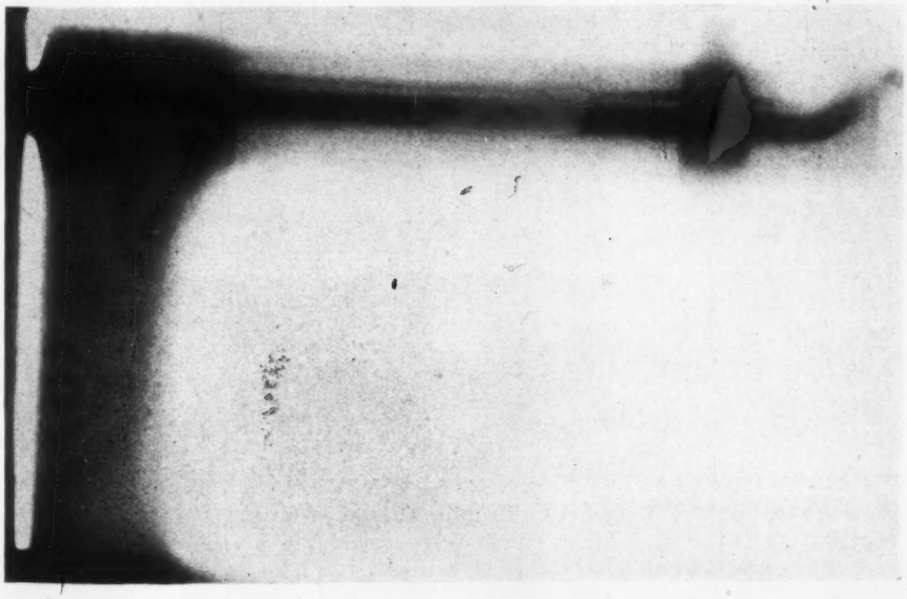


FIG. 15.—BRONZE CASTING. LITTLE CRACK AT THE END OF THE PIECE IS INDICATED BY A DARK SPOT

terial was defective. In this connection, it is remarkable that faults which lie horizontally to the X-rays can also be proved satisfactorily.

Examination of Ingots and Bars

Of great importance is the examination of cast ingots and bars before rolling or drawing to determine impurities and porosity. Fig. 16 shows a brass bar about 1-in. thick; there is slight porosity toward the edge. Surface variations have been fairly well suppressed by the use of a liquid absorber.

Fig. 17 is an extruded bronze bushing, showing little lack of homogeneity.

FIG. 18.—BRASS FITTING. UPPER HALF SHOWS LIGHT AREA OF PINHOLES. MIDDLE PART SHOWS CHAIN OF SMALL CAVITIES, DETERIORATING THE STRENGTH OF THE CASTING UNDER PRESSURE. DOWN TO RIGHT A GROUP OF BLOW HOLES

Examination of Pipe and Fittings

A rather complicated bronze casting is shown in Fig. 15. A little crack at the end of the piece is indicated by a dark spot. In Fig. 18 we show a brass fitting. The upper half shows a light area of pinholes; a series of almost connected small cavities are seen in the center of the casting, deteriorating the strength of the casting under pressure. Down to the right there is a group of blow holes. None of these defects was noticeable on the surface.

An iron pipe fitting is shown in Fig. 19. Considerable shrinkage (visible as lighter spots) can be recognized remarkably well. Fig. 20 is a zinc die casting. Air bubbles in the thread show up as light spots.

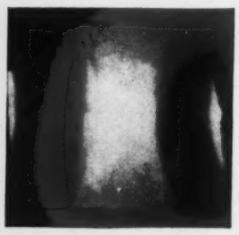


FIG. 19.—AN EXOGRAPH OF AN IRON PIPE FITTING.

Equipment for Making Use of X-Ray

The equipment used in making X-ray pictures consists of a high-voltage power plant capable of producing 280,000 volts, an X-ray tube mounted in a lead-covered steel drum to prevent the escape of X-ray except through predetermined openings, and an exposure cabinet provided with movable lead screens to surround the object under investigation. In addition, there is a photographic darkroom. With this equipment, articles ranging from sheet rubber 20 mil. thick to cast steel 4-in. thick have been examined in routine practice.

For practical inspection work with a fluoroscopic screen, a specially constructed outfit is available whereby the castings pass on a conveyor belt right through the X-ray field. One checker is able to inspect the entire output before leaving the plant, because the examination only affords a few seconds for each piece and some hundreds can be dealt with in an hour. Such equipment has proved of special value in the manufacture of die castings and light brass, steel and iron castings.

X-ray equipment, however, should not be installed until the adaptability of X-ray methods to the problems in hand has been demonstrated, and not then unless the benefits to be derived justify the cost. This would seem to make the tool unavailable to the organization with a small problem or a temporary difficulty. But fortunately some of the pioneers have installed equipment to take care of such cases, so that it is possible to evaluate any proposed use of X-rays without great expense.

In the realm of industry X-rays have yet to be established, and such is the conservatism of modern business that an enormous amount of energy must be expended in explaining obvious applications to skeptical individuals and organizations. The most powerful factor operating against innovation is the old and indisputable fact that "my father did perfectly well without it."

This idea, even when not expressed in words, is a convenient mental armchair in which to indulge the inherent laziness that characterizes certain people. The radiologist does not know all the problems of industry. He can only offer his rays as a new tool to the industrialist, and leave it to him to suggest the particular problem in his own sphere which they may help to solve.

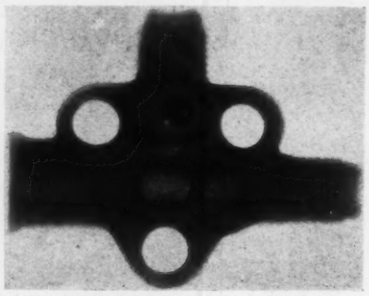


FIG. 20.—ZINC DIE CASTING. BLOW HOLES IN THE THREAD SHOW UP AS LIGHTER SPOTS

Air Conditioning *for* Efficiency

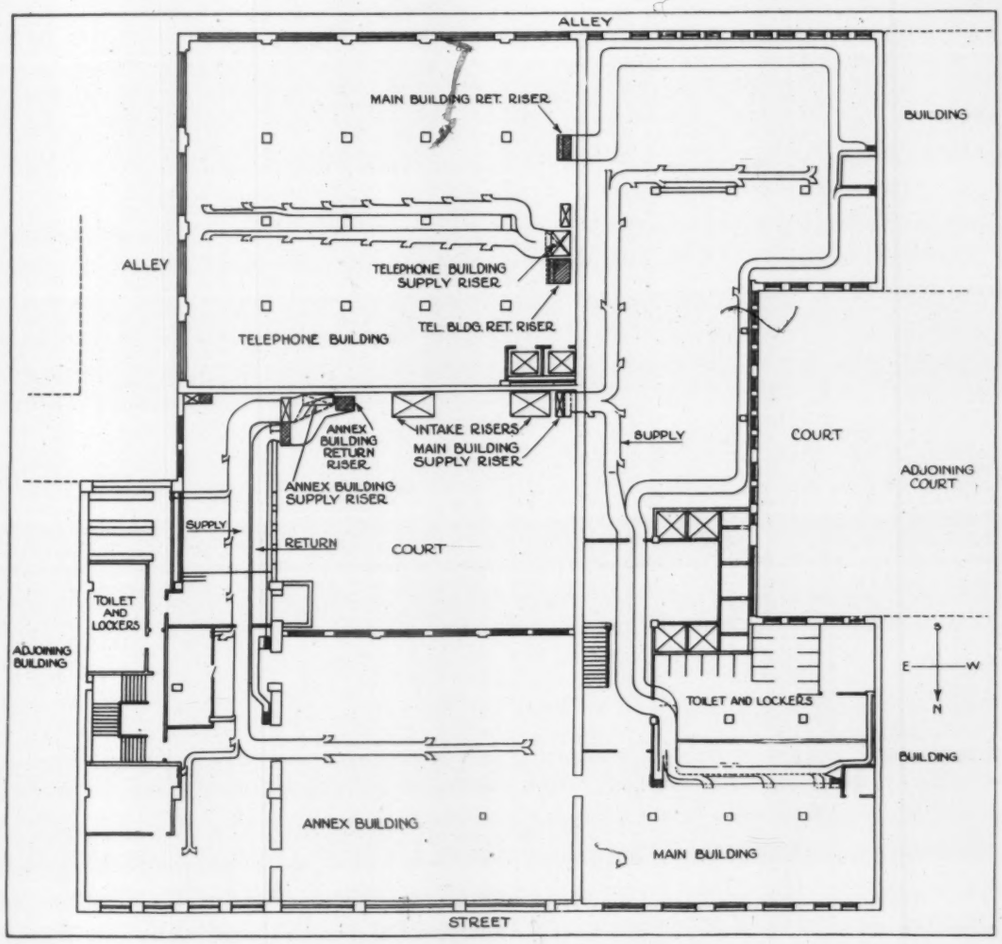
Engineering problems encountered in remodeling air conditioning equipment in office building

THE NEW art or science of air conditioning, in the last decade having conquered first the air conditioning of dining rooms and in rapid succession the air conditioning of theaters, hotels, industrial buildings, office buildings and banks for the purpose of improving or increasing production or profit, is now definitely in the field of air conditioning of offices for the purpose of promoting the health and comfort of the occupants.

In fact, the year 1929 may be set down as the year in which air conditioning for human comfort was inaugurated upon a major scale. May 1929 and the air conditioning installation in the Chicago Title and Trust building, Chicago, described in this article, mark the time and place of the appearance of a unique and outstanding example of this new trend.

In the Chicago Title and Trust building, 1,700 office people are employed in clerical work relative to the guaranteeing of land titles. There are also many other occupants of the building. It is estimated that, counting those who come from day to day into these offices to transact business, there is a total daily occupancy of 5,000 persons. The comfort of all of these people, aside from any other consideration was conceived to be important. It is interesting to note that these places for years have been ventilated by mechanical means providing approximately eight changes of air per hour. But in comparison with modern air conditioning, this method was considered inadequate and air conditioning highly desirable.

Jean S. Jenson of Neiler, Rich & Co., consulting engineers, Chicago, whose engineering works may be seen in the Northwestern Railway station and other prominent buildings in Chicago, and who has been the engineer for the Chicago Title and Trust Co. for more than twenty years, played a vital part in this new departure.

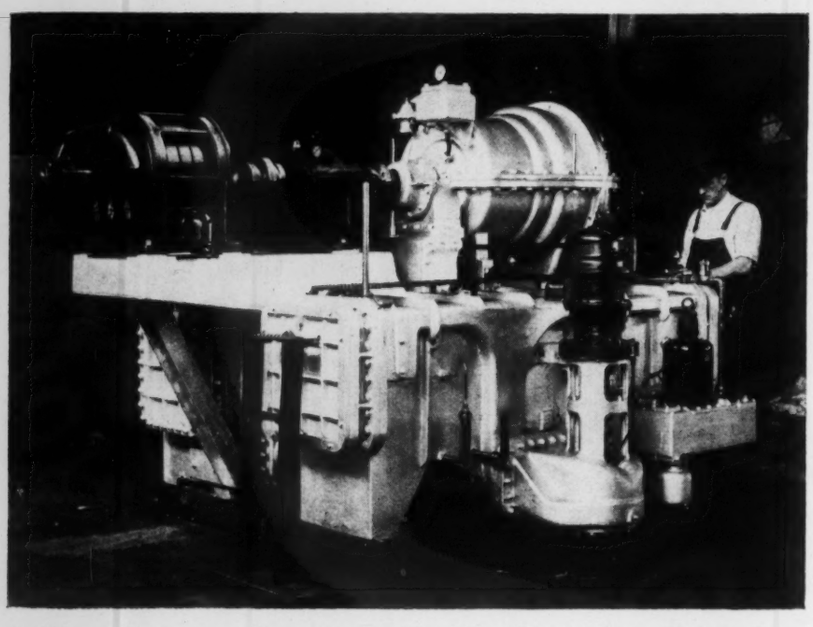


TYPICAL FLOOR PLAN SHOWING SUPPLY AND RETURN TRUNK DUCTS AND RISERS

He and the owners of the building believe that human comfort in winter and in summer is an object worth seeking.

The physiological data from the laboratory of the American Society of Heating and Ventilating Engineers, as well as the experience of many industrial concerns, have demonstrated that efficiency in factories may be increased by favorable air conditions and that this is an economic move which can be evaluated in dollars and cents. The owners and engineers of this building, however, did not put into the balance against the cost of the installation any estimate relative to increased efficiency or any increase in the amount of work which the employes might do. The only consideration was the comfort of the employes.

There are notable instances of installations in office buildings for the purpose of making the offices more rentable, but here the increased rentability of office space was not considered, for only the employes of the Chicago Title & Trust Co. will receive the benefits of this new system. This installation, it is predicted, will be a forerunner of many such installations and, in fact, at the present time, air conditioning for human comfort alone is finding application in similar instances throughout the country. Various public utility companies recently have installed or are considering the installation of air conditioning equipment for offices and display rooms. Certain department stores are planning air conditioning installations for human comfort alone and it appears that 1929 will mark the advance of a new and rapidly developing field for air conditioning. Customers naturally patronize the stores that provide air comfort.



A 300-ton Centrifugal Refrigeration Unit Was Used in the Chicago Title and Trust Building. This 100-ton Machine Is the Same type

Problems Involved Air Conditioning Existing Buildings

An interesting feature of the installation in the Chicago Title and Trust buildings lies in the fact that it had to be adapted to existing buildings. The ventilation has been brought up to date from time to time as new and improved equipment became available. This job is also unique due to the fact that three adjoining buildings are involved. These are known as the "main" building, the "telephone" building and the "annex," all of which are operated from one central plant. Four of the 16 stories of the "main" building, all five stories of the "telephone" building, and all four stories of the "annex" are occupied by employes of this concern, and is the space which is air conditioned. The other stories of the "main" building are occupied by the office tenants of the building.

Installing air conditioning equipment in old buildings involves many problems. In these three buildings the space was limited. It required a lot of ingenuity to lay out the equipment in the space available. The unobtrusive outlets into the rooms, which are a feature of newer installations, here had to be ignored. While not offensive to the eye, these outlets could not be treated in the artistic manner permitted on new jobs. Old trunk and riser ducts had to be reckoned with, and a number of them were used.

In air conditioning, unlike ventilating, careful calculations must be made of air quantities in which selections regularly are made on empirical data. Such calculations were applied in determining the character of the various diffusing outlets which had to be provided, as well as for the outlets in old ducts and risers. In order to use as much of the old installation as possible, it was found necessary to take some liberties with accepted air duct velocities, although an effort was made to deviate as little as possible from accepted standards.

There are three sets of mechanical equipment, each set consisting of a preheater, a reheater, a dehumidifier, a fan and a motor to drive the equipment. Although this equipment is located in one central plant, one set of equipment is used for each building, thus providing for each building definite and automatic control. One refrigeration unit supplies cold water to the three dehumidifying units.

This installation was so designed that the water from two of the dehumidifier tanks drained to the third dehumidifier tank which serves as a collecting basin. From this tank, the water is picked up by a centrifugal pump and forced through the refrigeration cooler to the spray headers in the dehumidifying chambers. In the refrigeration cooler, the water is cooled to a predetermined temperature. The factors governing this temperature are the infiltration of air, number of occupants, heat load, and heat gain. The refrigeration unit has automatic control of the amount of condensing water for the purpose of promoting economy of water and of power.

The Cost of Air Conditioning

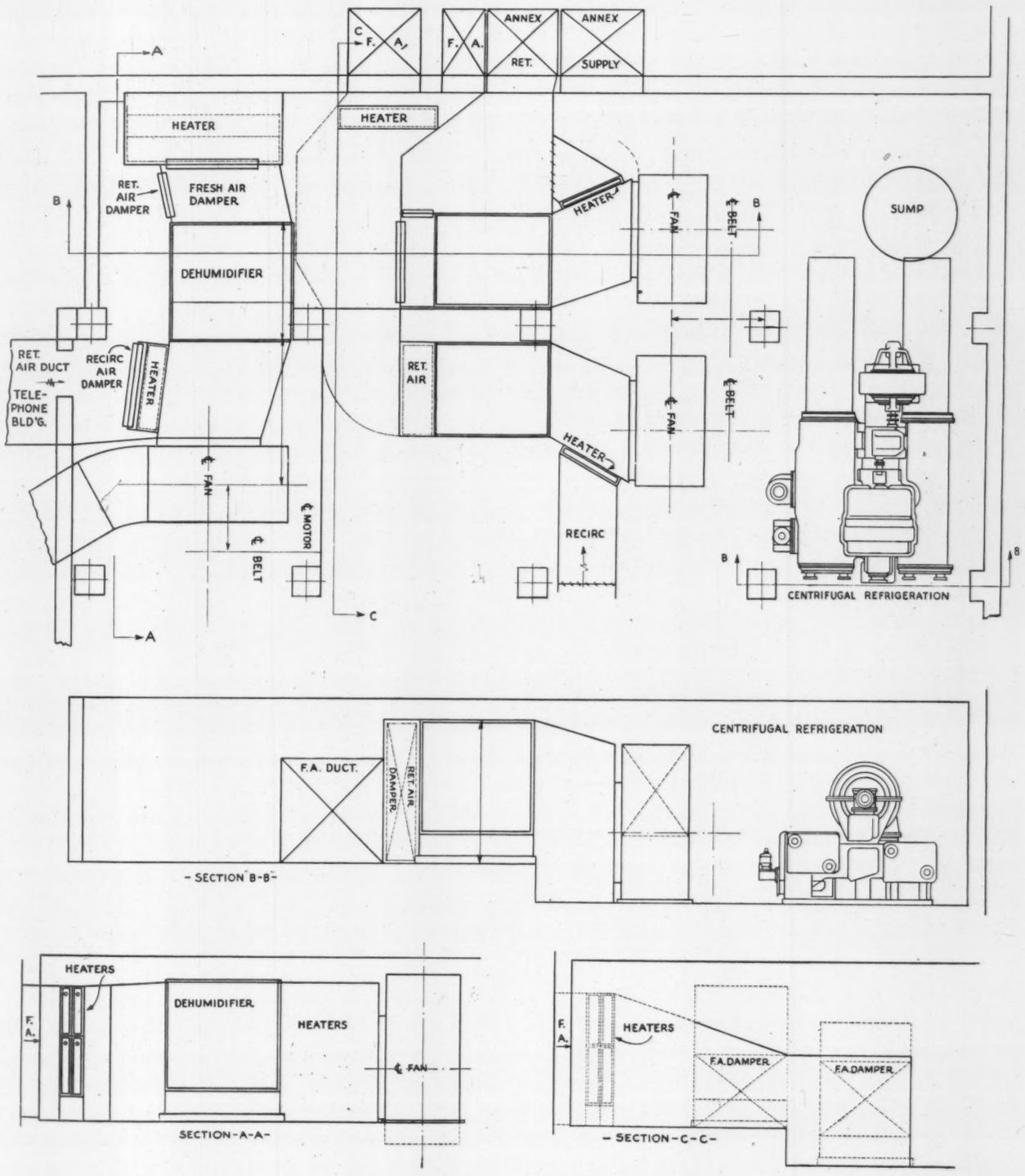
While this investment of something like forty to fifty dollars per employe was primarily for the comfort of the occupants of the buildings, it is believed that other benefits will come in the form of increased efficiency, less sickness, elimination of odors, a partial or

total elimination of the well known afternoon lag in production, etc. While these have not been evaluated in terms of dollars and cents and were not the prime consideration, it will be interesting to the owners of the Chicago Title & Trust Co. and to the engineer of the building to observe what these benefits are. It is estimated that the cost of operation of the air conditioning equipment will amount to $1.00 to $1.25 per year per person, based upon the assumed occupancy of 1,700 persons per day.

The cost of air conditioning may vary greatly in different parts of the country and under different structural requirements. Here, however, are some costs which have been made public and which may give some idea of these costs. Variation in above factors may increase or decrease these figures as much as 25 per cent.

Hiram G. Walton of Smith, Hinchman & Grylls, Detroit, Mich., has the credit for the working out of the table on the next page.

The proportion of the cost of heating and ventilating



Typical Diagram of Arrangement of Ducts and Mechanical Equipment

equipment in larger structures in New York, in Chicago and in the South has been found in various instances to be as follows: In a hotel, 2.6 per cent; in several office buildings, 5.7, 7.1, 7.7, 4.4, and 4.0 per cent; in several bank buildings, 5.8, 5.1, 4.3 and 5.3 per cent.

COMPARATIVE AIR CONDITIONING DATA

	Bank and Office Bldg.	Dept. Store	Dept. Store	Dept. Store	Bank and Office Bldg.	Theater	Restaurant
Cost in $ per sq. ft. of Floor Area	$1.50	$1.87	$1.75	$1.60	$0.95	$4.07	$2.88
Cost in $ per cu. ft. of Room Volume	0.107	0.166	0.14	0.147	0.080	0.20	0.26
Cost in $ per c.f.m. of Air Cond. System	0.92	1.20	1.03	1.23	1.05	0.81	1.17
Cost in $ per ton of refrigeration	384.00	345.00	444.00	475.00	368.00	398.00	365.00

In the South, the average cost for cooling an average office is said to be about 20 cents per day during eight months of the year. This includes depreciation and interest on the investment. In the South, heating for four months of the year costs about 15 cents per day per office. This also includes all cost which can be directly chargeable to the maintenance of human comfort.

Obviously an office that is cool in summer can be rented more easily than one that is not cooled. It would seem that if noises can be eliminated with no detriment to the air supply, this also would be valued by office tenants. It would appear that balancing the number and area of windows (the great heat wasters) against the loss of heat and the growing efficiency of artificial lighting would come to be a consideration in future building construction.

From data gathered throughout the country it is believed that the cost of air conditioning—maintaining control of temperature, humidity, and air motion throughout the year in the higher class office buildings—warrants an increased rental charge of 10 to 15 per cent. Some maintenance engineers for buildings are in the habit of charging 5 per cent of this to increased expense of operation and the remainder to increased rentability of offices. The average cost of operating an air conditioning system during the heating period in the latitude of Chicago, is approximately 5 per cent greater than the operating cost of heating alone. Air conditioning service for twelve months of the year is said to cost about 10 per cent more than the cost of heating alone for six months of the year.

With a duct system as used in office buildings, about 5 per cent of the floor space is saved as compared with direct radiation, if included in this is the space close to the radiator which is not usable on account of excess heat. Some engineers, in figuring air conditioning costs and its advantages, balance 5 per cent of the increased operating cost with the value of increased floor space and the other 5 per cent is charged to increased cost of operation.

In the meantime, new types of radiators have been developed which also may be removed from the floor space and put into wall recesses. Unit heaters are available which heat and filter the air and drive it from the office to the outside or bring it from the outside into the office. These and other developments show a decided trend of public consciousness, as advertising men term it, toward the modern conception of air conditioning. It is claimed by some manufacturers of these heaters that the additional value of floor space made available by recessed heaters about balances the additional cost of the heater and installation.

New Factors in Air Conditioning

New significant factors that have been injected into the science of air conditioning in recent months are (1) increased rentability of building space following the installation of air conditioning equipment, (2) increased rentability of lower floors where, on account of air conditioning making it possible to keep the windows closed, street noises are kept out, (3) the increased use of lighting which provides daylight visibility and which eliminates to some extent the necessity for windows. In factories, particularly, is noticed this new tendency to increase the artificial lighting and decrease the window area. With lessening cost of artificial lighting, an increased demand for elimination of noise and extended application of air conditioning, it is conceivable that window area may be decreased in certain types of structures.

The trend in conditioning of office buildings frequently is to condition the first six or eight floors and charge an advanced rental for offices on these floors. Since the noise and dirt are largely eliminated on account of the closed window, it is stated that many tenants prefer these floors to the upper floors which, heretofore, have been in greater demand. Another trend is to charge the same rental for all offices, believing that air conditioning for the first six or eight floors about balances the formerly greater attractiveness of the upper floors.

Another effect of air conditioning, one or more examples of which may be seen at the present time, is the placing of more employes in a more limited space. In one instance, a business concern abandoned the project of putting up a new building, believing that by using air conditioning in its one existing building it could increase the occupancy of that building without lessening either the comfort or the amount of work done by the employes.

The use of ozone and ionization of air are factors that are coming into use and may have to be reckoned with in air conditioning installations in future years.

Since heating is the major factor in air conditioning, and since the other factors of humidity, cleanliness, air motion, and perhaps the use of ozone or ionization of air, are coming rapidly into demand for human comfort, it is conceivable that the better heating contractors will some day become air conditioning contractors. In fact, the number of air conditioning contractors has been increasing from year to year.

At the present time, however, exact knowledge of the art or science of air conditioning is largely in the minds of relatively few persons and much of this knowledge is based upon experience. In air conditioning, many factors must be considered, involving summer as well as winter temperatures, moisture given off by occupants of buildings, humidity of the air, introduction of proper amounts of outside air, latitudes in which the building is located, etc., and no definite rules can now be set down that will serve for all latitudes and all conditions. It is apparent, for instance, that the heating problem in northern latitudes is of greater importance, while in some

southern portions of the country the cooling in summer is of major importance.

Character of Equipment

Every one of the three sets of equipment in the Chicago Title and Trust building consists of a preheater, a reheater, a dehumidifier, a fan and a motor to drive the equipment as explained above. A typical diagram of one arrangement is shown in this article. The three sets of equipment are served by one 300-ton centrifugal refrigeration unit using as a refrigerative a chemical combination CH_2 CL_2 known as dichloromethane. The refrigerator is of the spray type, attached to which is the cooler of the shell and tube type with bronze tubes expanded into bronze tube sheets. About 150,000 cubic feet of air per minute are used in the three buildings. No exhausts are used except for the toilets. Instead of wasting the air through the roof, as is frequently done, the air finds exit through the entrance of the building and the coolness is noticeable by passersby on the sidewalk. This serves the dual purpose of maintaining a positive pressure on the building and advertising to passersby and to those who enter the building, the fact that comfort of the occupants of the building in summer as well as in winter is being taken care of.

The air is washed. No ozone is used nor is there any attempt to ionize the air. The power is supplied by a 480 horse power direct current motor, providing for a total resistance of 1½ inches of water. The fans are of the centrifugal type. About 1,000 gallons of cooling water are used per minute in the dehumidifiers in summer. This, of course, is used over and over again until such time as it is deemed necessary to clean the dehumidifier tanks. This cleaning is done about once a week.

Procedure, Maintenance and Control

It is interesting to observe the attitude of the public toward new public comforts or conveniences. Appearing first as luxuries, they soon acquire the status of comforts that are demanded by a few, and shortly afterwards they become public necessities or public utilities. And it is encouraging to observe that the cost of these new comforts is decreasing quite rapidly. In less than four decades electric lighting, plumbing, telephones, phonographs, automobiles and radios have become a necessity to 70 to 80 per cent of the people in this country. And now comes air conditioning.

The cost of electric lighting has decreased consistently over a period of more than 30 years. Air conditioning, however, has shown a much more rapid decline in cost, which, in general terms, and considering its broad application to various fields, may be regarded as about 30 per cent over a period of about 8 years. And the consequence is that air conditioning is today emerging rapidly from the status of a luxury to that of a public necessity. This is due to a great extent to the fact that from year to year more is learned about procedure, maintenance and control.

View of Duct Work in Fifth Story of Annex Building. Note the Care Taken to Make Ducts of Good Appearance

In the plant described, designed to meet the outside weather demand of 10 degrees F. below zero in winter and any degree of temperature that may be encountered in summer, the procedure, maintenance and control will be guided by this knowledge and experience. In the cold months, there will be maintained between 35 and 40 per cent relative humidity with a dry bulb temperature of 72 to 74 degrees F. This, of course, will be influenced by the number of occupants of the building, the number of males or females, the kind of clothing they wear, etc.

When one enters into one of these three buildings, with the weather at 90 degrees F. outside for instance, he likely will find the inside temperature about 78. When the outside air is at 95 degrees F., the inside air will be maintained at about 80 degrees.

The air, as it enters the various rooms, will be from 8 to 10 degrees above or below the desired temperature. In the summer time, in order to maintain an 80-degree temperature, the air might be delivered at 70 or 72 degrees. In winter the entering air will be maintained at a temperature a few degrees higher than 70 or 72, depending upon the temperature of the outside air.

The manual control of the system consists of starting, stopping and regulating of the speeds of the various motors. One man operates all of the air conditioning equipment under the direction of the chief engineer.

The windows are closed in summer as well as in winter. The public is now acquainted with the open window and with ventilation to some degree, but will now be compelled to consider the closed window with air conditioning and its benefits. In this mechanical age they will be compelled to decide in their own minds as to the correctness or incorrectness of a basic belief in air conditioning, which is that anything that is done manually can be done more economically, in a more uniform manner and more surely by mechanical means.

Strange it is that the human race that for untold centuries has known how to protect itself from excessive cold, waited until the twentieth century of the present era to learn how to protect itself from excessive heat.

Steam Distribution Piping Involves Two Problems

Discuss Flow of Steam at District Heating School

TWO entirely different problems are involved in the design of piping for steam distribution in heating systems: first, the design of piping systems within the building, that is, between the boiler or reducing valve and the radiators, and, second, the design of systems for the distribution of steam over long distances as between a central district heating plant and a number of widely distributed buildings. Within a building, quietness of operation limits the velocities to conservative values which are determined by experience. In an underground distribution system, velocities are limited only by the allowable pressure drop or, in other words, the initial and final pressures.

These are some of the observations of H. L. Solberg, professor of mechanical engineering, Purdue University, Lafayette, Ind., and are from an address given at the district heating school conducted at that institution May 20 to 25, 1929. The discussion dealt only with the flow of steam in distribution systems or where pressure drop controls the sizing of the pipe.

Prof. Solberg explained that the friction loss in a pipe varies

(1) Directly with the square of the velocity.
(2) Directly with the area of contact between the steam and the pipe, i.e., the length.
(3) Directly with the density and
(4) Is independent of the pressure against the pipe wall.

The usual formulas for sizing pipe are given on page 611 of the National District Heating Association handbook and, omitting the formula of Ledoux, may be divided into two types:

$$P = k\left(1+\frac{3.6}{d}\right)\left(\frac{W^2L}{cd^5}\right) \quad \ldots\ldots (1)$$

$$P = K\left(\frac{W^2L}{cd^5}\right) \quad \ldots\ldots (2)$$

Where P = drop in pressure in pounds per sq. in.
W = weight of steam flowing in pounds per minute.
L = length of pipe in feet.
C = mean density of steam, pounds per cu. ft.
d = diameter of pipe in inches.
k and K are constants.

The Babcock-Uneven-Carpenter equation, (1), differs from equation (2) in that the coefficient of friction varies with the pipe diameter instead of being constant. Both equations give substantially the same result for a 2½-inch pipe. For larger pipe sizes, the Babcock equation gives lower pressure drops. Data were presented to show the difference in the results obtained by the use of the two types of equations. The Babcock equation is the one which is most commonly used and is recommended in preference to the second type of equation.

The Babcock equation may be written in the form

$$W = 87\sqrt{\frac{Pcd^5}{L\left(1+\frac{3.6}{d}\right)}} \quad \ldots\ldots (3)$$

$$\text{or } W = \left[87\sqrt{\frac{P}{100}}\right]\left(\sqrt{\frac{d^5}{1+\frac{3.6}{d}}}\right)\left[\sqrt{C}\right]\left(\sqrt{\frac{100}{L}}\right) \quad \ldots (4)$$

A table was presented in which the values of each of the four expressions in parenthesis are tabulated throughout the range usually encountered in the sizing of pipe. The use of this table greatly simplifies the labor of calculating pressure drops or pipe sizes. A number of problems were presented to illustrate the use of the table.

The chart shown on page 621 of the National District Heating Association handbook was described in detail and its use illustrated by a number of typical problems. The graphical solution of the Babcock equation by means of this chart is the simplest method of determining pipe sizes.

The influence of valves, fittings, etc. on friction loss in piping was also considered as well as the variation in the allowance for equivalent length of straight pipe, as recommended by various authorities.

The pipe installed in distributing systems should be as small in diameter as possible in order to reduce the investment and also the heat loss due to radiation. Consequently, high initial pressures and large pressure drops are desirable. The pipe should be designed to result in the maximum allowable pressure drop due to friction.

SASKATCHEWAN POOL TERMINAL NUMBER 7 FROM THE WATER SIDE

Dust Explosions Controlled in a Terminal Elevator

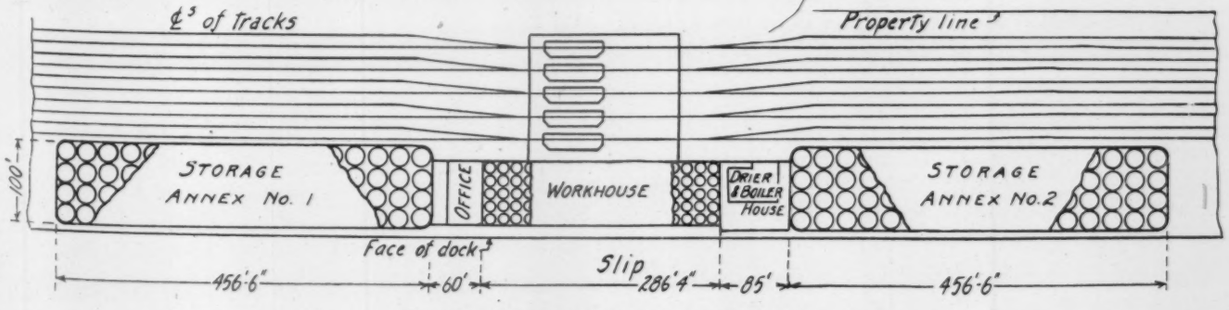
By Albert E. Macdonald, M. Sc.
Professor of Civil Engineering, University of Manitoba

FROM the lowly grain warehouses of the middle part of the 18th century through the several stages of combustible wood and non-combustible brick, tile, steel and reinforced concrete construction, the great terminal grain elevators of today have evolved. At that time, crops were light and shipments few and all grains were handled in sacks. The invention of the elevator leg by Oliver Evans in 1780 and the ever increasing yearly crops gradually changed the grain warehouse to the grain elevator and sack handling of grain to bulk handling. With bulk handling of grain, the installation of separators, the increase in size of elevators and better and more rigid construction, came the consequent dusty floors and large dust accumulations on spouting, machinery, ledges and side walls.

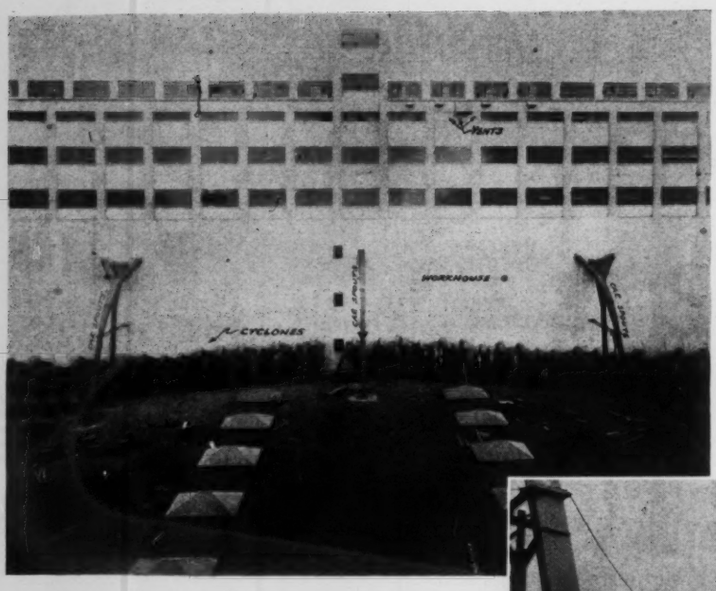
The first dust explosion to attract attention on this continent happened at Minneapolis in 1878. At intervals since that date, disastrous explosions have occurred in both the United States and Canada. In three of such occurring in grain elevators, the net result was the loss of 30 lives and property and grain damage running into millions of dollars.

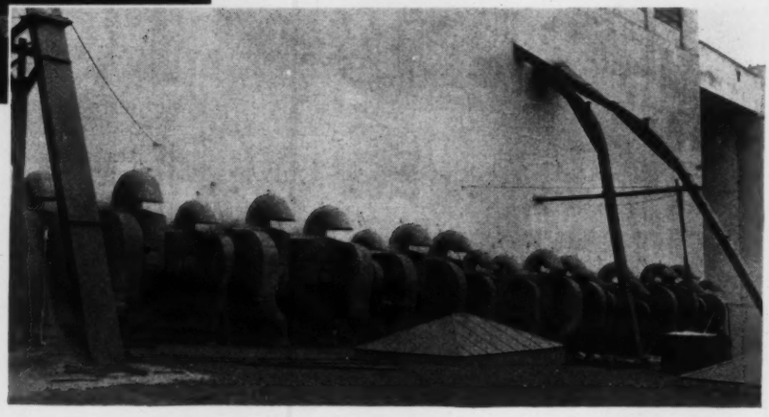
The Reasons for Dust Explosions

Dust and gas explosions appear very similar. It is impossible to produce a spontaneous explosion in either case and the proper mixture of air is required as is also an external agent such as a flame. If the theory is accepted that an explosion is but a rapid transmittance of flame from one molecule, or dust particle, to the next, there is established a definite relation between fire and explosion, the violence of



GROUND PLAN OF SASKATCHEWAN TERMINAL





ABOVE: ASSEMBLY OF CYCLONES OVER TRACKSHED ROOF FOR SEPARATORS ON FIRST FLOOR OF WORKHOUSE. AT RIGHT: CLOSE-UP VIEW OF CYCLONES OVER TRACKSHED ROOF

The most modern and efficient terminal grain elevator in the world, and the largest ever built under one contract, was erected in 1928 at Port Arthur, Ontario. This elevator was placed in commercial operation on October 23, just five and a quarter months from the pouring of the first concrete.

Built entirely of reinforced concrete, Saskatchewan Pool Elevator No. 7, or Pool Terminal No. 7 as it is better known, lies at right angles to the shore line and extends well out into Thunder Bay. It consists of a central workhouse, an inshore and an outshore storage annex, trackshed and dock on opposite sides of the workhouse, an office and substation building between the workhouse and the inshore storage and a drier and boiler house between the workhouse and outshore storage.

The elevator has a total storage capacity of more than 7,000,000 bushels, of which 900,000 are in the workhouse and the remainder in the storages. The trackshed has five entrances, each entrance being provided with a car dumper and a hand-pit. Each car dumper is capable of unloading an average of 7 cars per hour and the plant is designed to handle 500 cars per day under peak operation. Elevator legs provided are 5 receiving legs at 25,000 bushels per hour, 6 shipping legs at 25,000 bushels per hour, 14 cleaning legs at 8,000 bushels per hour, 2 screening legs at 8,000 bushels per hour, 1 drier leg at 8,000 bushels per hour. Conveyor and leg belting of five and seven ply has a total length of 6.7 miles. Nine boat spouts, drawing from a total shipping bin capacity of 90,000 bushels, give a shipping capacity to boats of 150,000 bushels per hour. The drier is a 1,000 bushel per hour steam drier, equipped as recommended by the Canadian Research Council. The plant contains 177 motors totalling 5,736 h.p.

The Dust Collector and Ventilating System

The dust collector and ventilating system was the largest contract ever placed in elevator work and is unusually complete. An air compressor system also is installed.

For collecting sweepings, a complete sweeper system is installed, consisting of fans, cyclones and galvanized steel piping.

the latter in this case depending upon the fineness of the dust and the humidity.

Much damage to property sometimes has been caused by an extensive fire which was the product of a primary explosion of light intensity. Frequently this primary explosion has been followed by an additional one, or more, each succeeding explosion being more violent than the previous one. As the subsequent explosions have assumed large proportions, it would appear that the dust accumulated throughout the plant was thrown into suspension by the primary, or previous, explosion. In plants where dust has not been allowed to accumulate, due to the fact that there has been little dust in suspension, the presence of a spark or flame has sometimes caused a fire but no violent explosion has occurred.

Matches, lighted cigarettes, lanterns and similar open flames, sparks produced in dust collecting fans and static discharges from machinery have been among the sources of ignition of the suspended dust.

How to Control Explosions with a Dust Collector

An efficient dust collector and ventilating system is one effective means for the control of dust explosions. Such a system prevents the accumulation of dust in the plant, thereby lessening the amount of dust in suspension and eliminating that which a concussion might throw into suspension. Some special structural features also are desirable.

Cyclones to the number of 38 are furnished for 52 separators on the workhouse first floor and are attached to the exterior wall of the workhouse just above the trackshed roof. One cyclone is furnished for each of 20 large receiving separators, one for each two of 20 smaller separators, and one for each two of 12 (ultimate installation to be 16) wheat and oats separators. Piping from the large separators to the cyclones is 25-inch diameter, and from the smaller and wheat and oats separators is 12- and 10-inch diameter respectively. Air outlets from all cyclones are provided with hoods to prevent the weather from entering. The cone of these cyclones is made of No. 18 and the remainder of No. 20 gauge galvanized steel.

Four cyclones are situated one over each of four separators on the distributing floor, each cyclone venting independently to the open air on the trackshed side of the elevator.

A large cyclone dust collector is located on the distributing floor and spouts into the screenings bin. It is made of No. 14 gauge steel and all the dust collector system throughout the building discharges into the screenings bin through it. This cyclone also vents on the trackshed side.

Two dust fans, of the slow speed exhaust fan type, direct-connected to motors, are installed, one on the first floor and one on the distributing floor. The fan on the first floor is operated by a 125 h.p. motor at 585 r.p.m. and the fan on the distributing floor by a 40 h.p. motor at 875 r.p.m.

Grain traps, designed to take out grain and heavy materials of the sweepings are installed, one in conjunction with the fan on the first floor and one on the bin floor below the motor and fan located on the distributing floor.

Sweep-ups, provided with self-closing valves, are located throughout the workhouse and in the trackshed basement as follows: workhouse basement and first floor, 8 each; bin, distributing, scale and top floor, 4 each; trackshed basement, 6. A suction line from the dust collector tower of the drier is connected to this system.

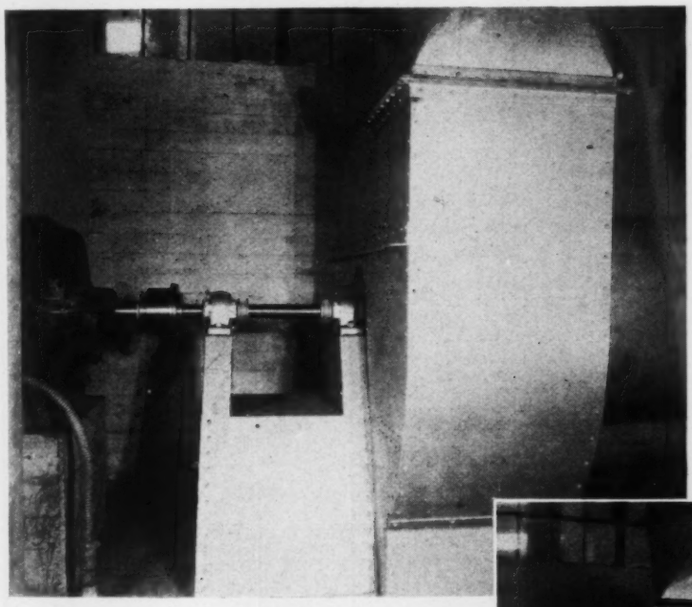
Suction lines with suction hoods are provided at each of the six head pulleys of the basement shipping belts. These suction lines have direct connection to the grain trap and are independent of the remainder of the system, each line being furnished with a valve so that it can be cut off when the corresponding belt is not in use.

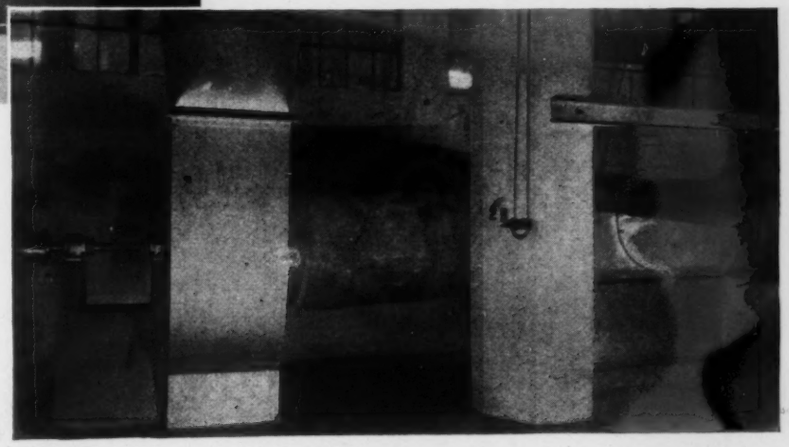
All piping up to and including 12-inch diameter is made of No. 24 gauge galvanized steel and above 12-inch is of No. 22 gauge. The pipe from the plate fan to the dust bin cyclone is of No. 20 gauge. All elbows have a radius of two diameters of the pipe and are made two gauges heavier than the straight pipe.

Branch lines throughout the elevator are equipped with positive, easy operating valves. Hand holes with airtight covers are provided in all cyclones and at all necessary points in the system.

Piping and sheet metal work throughout the system is galvanized and all joints in the cyclone collectors and in piping are riveted and soldered air and water tight.

A dust and ventilator pipe is provided for each of the eleven sets of scales and for the garners over the scales. The chief purpose of this ventilation is to relieve the scale hoppers of the air pressure caused by the sudden discharge of grain from the garners and from the scales. A 10-inch diameter 3/16-inch plate steel pipe, opening into the scale hopper at its base, extends from the bottom of each of these garners to above the top of the garner. At this point it is capped with a 12-inch diameter galvanized steel pipe which extends up through the workhouse roof and terminates in a ventilator. A connection from the top



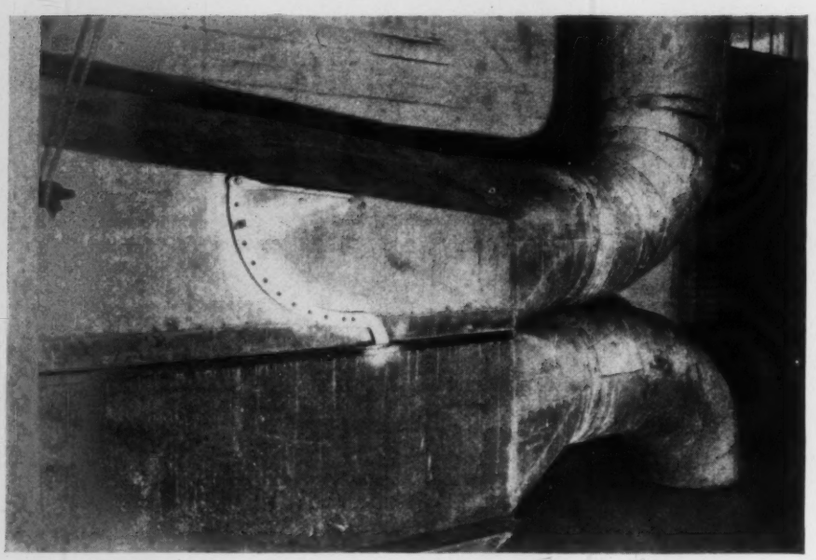


Above: Motor, Flexible Coupling, and Dust Collector Fan on First Floor of Workhouse. At Right: Grain Trap and Dust Collector Fan on First Floor of Workhouse

of the garner to the 12-inch pipe gives ventilation to the former.

To relieve any air pressure in the elevator legs, a ventilator pipe of galvanized steel extends from each elevator head up through the workhouse roof.

All workhouse shipping bins vent to the outer air by means of ventilator pipes. These are turned down to keep out snow as well as the rain.



GRAIN TRAP ATTACHED TO DUST COLLECTOR FAN ON FIRST FLOOR OF WORKHOUSE

Compressed Air

For the cleaning of dust from motors and inaccessible places, air piping of 1-inch diameter, delivering 60 pounds pressure, extends from the air compressor room throughout the plant to locations where motors are installed. It reaches to within 30 feet of every motor in the elevator and is provided with valves and ½-inch hose connections. Five 50-foot lengths of ½-inch pneumatic tool air hose are part of this air equipment. Each length is complete with one hose-to-pipe coupling and one blow gun. All air outlets are furnished with reducers to take the hose-to-pipe coupling.

Structural Details

To act as a safety valve and prevent the building up of high internal pressures in the elevator, all building units are provided with large window areas and in the workhouse and storage cupolas the steel sash extends from pilaster to pilaster and, in the majority of cases, rests on thin curtain walls, the latter keyed into the pilasters for a distance of about 1 inch. All windows are glazed with plain glass and the central portion of the sash tilts to provide ventilation.

The side walls of the belt galleries connecting the workhouse bin floor and storage cupolas are made of metal lath, secured to the steel trusses which span the space between the buildings, and plastered both sides to give a 2-inch thickness of wall. These walls offer little resistance to explosive energy.

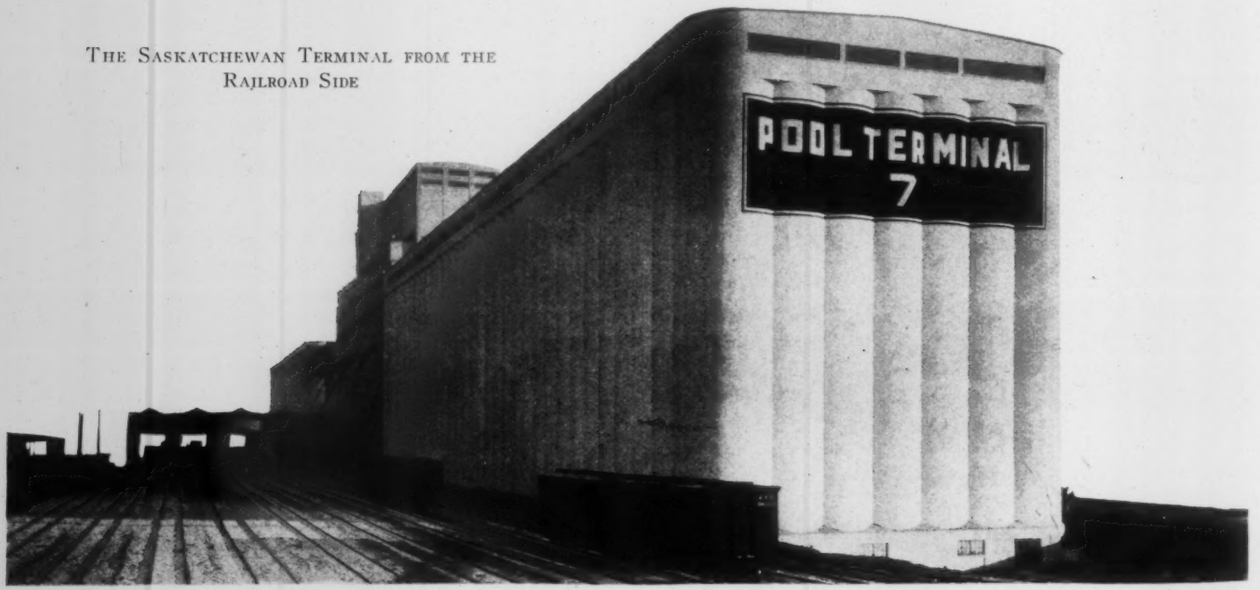
The walls of all storage bins extend solidly to the top of the bins and are capped by the bin floor slab. There is no communication between bins except in special cases where two bins are interconnected and used as one. The openings in the bin floor slab through which the bins are filled serve as vents for the bins in the storage annexes. The majority of these openings are provided with gratings and with hinged covers of sheet steel.

The basements of the storages are provided with windows, some of which are always left open while the elevator is in operation. This permits of the free circulation of air under the storage bins.

All car entrances to the trackshed are provided with roller shutter doors which are kept open while grain is being received.

All elevator legs are of steel and extend from the boot to the head. This limits the size of the chamber and consequently the quantity of dust present.

THE SASKATCHEWAN TERMINAL FROM THE RAILROAD SIDE



Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers
JOURNAL SECTION

JUNE 1929

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FIG. 1. WARM-AIR HEATING RESEARCH RESIDENCE, AT URBANA, ILL.

Analysis of the Over-All Efficiency of a Residence Heated by Warm Air

By A. P. Kratz[1] (Member) and J. F. Quereau[2] (Non-Member), Urbana, Ill.

Acknowledgments

THE data presented in this paper were obtained in connection with an investigation which is being conducted by the Engineering Experiment Station of the University of Illinois, of which M. S. Ketchum, Dean of the College of Engineering, is Director, in co-operation with the *National Warm Air Heating Association,* under the supervision of A. C. Willard, Professor of Heating and Ventilation and Head of the Department of Mechanical Engineering. The basic data from which this paper is prepared are given in Engineering Experiment Station Bulletin No. 189.[3]

Under the terms of a co-operative agreement between the *National Warm Air Heating Association* and the University of Illinois, a very extensive study of furnace heating problems has been made, using first an experimental plant with auxiliary equipment in the laboratory, and later a typical modern residence erected by the association for the express purpose of correlating and extending the work in the laboratory to the conditions of actual installation. It was in this residence that the data herein presented were obtained.

Introduction

The design of house heating plants has usually been based on the assumption that the only heat available for compensating for the heat loss from the house would be that actually delivered to the rooms by the heating plant. Thus a boiler or furnace operating at 60 per cent efficiency would be expected to utilize 60 per cent of the heat of the fuel burned and to deliver this heat at the boiler nozzle or furnace bonnet. The loss between the heating unit and the rooms would then be deducted and only the remainder, usually less than 50 per cent of the

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[2] Special Research Assistant, Engineering Experiment Station, University of Illinois.

[3] "Investigation of Warm-Air Furnaces and Heating Systems, Part IV, Research Residence," by A. C. Willard, A. P. Kratz and V. S. Day, Engineering Experiment Station Bulletin No. 189.

For presentation at the Semi-Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Bigwin Inn, Lake-of-Bays, Ontario, Canada, June, 1929.

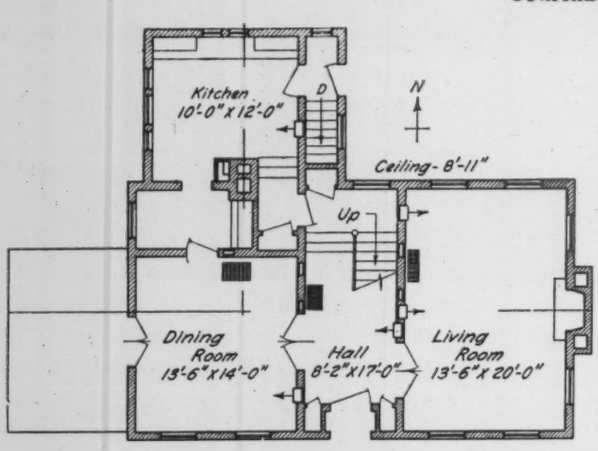

FIG. 2. FIRST FLOOR PLAN WITH LOCATION OF WARM-AIR REGISTERS AND COLD-AIR RETURN GRILLES (FOR THIRD INSTALLATION)

heat of the fuel, would be regarded as available for actually heating the rooms.

Data obtained in the warm air heating research residence have indicated that in a self contained heating system much of the assumed waste heat is available for heating the house and is utilized quite efficiently. With efficient combustion, most of the 50 to 60 per cent usually assumed as loss, is used for heating the house and results in a very high over-all house efficiency. It is with this over-all house efficiency that this paper is concerned.

Description of Residence

In all respects, the research residence, Fig. 1, is of standard frame dwelling construction, with the single exception of the studding, which is 2 in. × 6 in. instead of the usual 2 in. × 4 in. This permits the use of larger wall stacks, or vertical heat pipes, than could be used in 2 in. × 4 in. construction. The wall section is as follows: weather boarding, building paper, ship-lap siding on 2 in. × 6 in. studding, lath, and plaster with rough sand finish. The coefficient of heat transmission for this wall section is 0.20 B.t.u. per square foot per hour per degree fahr., at a wind velocity of 15 mi. per hour. The walls are not insulated, and no weather stripping is used at the windows and doors. Interlocking copper shingles are used on the roof. The research residence has not been occupied by a family. Instead, a caretaker has lived in the residence, and the daily occupants have been the members of the research staff. Furniture, rugs, and window shades and curtains were provided. No cooking or other domestic activities requiring the application of heat were carried on. Thus the kitchen,

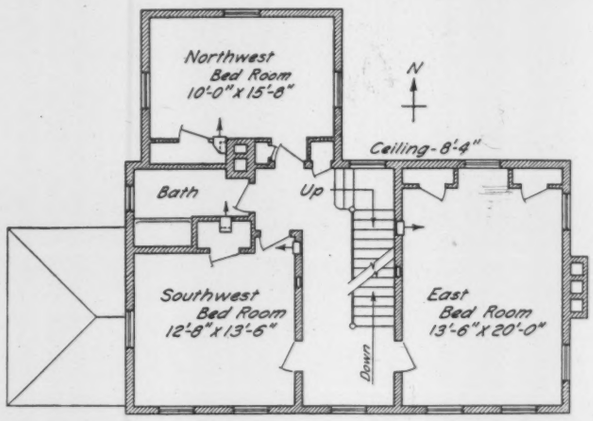

FIG. 3. SECOND FLOOR PLAN WITH LOCATION OF WARM-AIR REGISTERS

as well as all other rooms, received heat solely from the heating system.

The room arrangement and exposures are shown in Figs. 2, 3, and 4. It should be noted that only one room, the bath-room, has a single exposure to

TABLE 1. LEADER PIPE, STACK, AND REGISTER SIZES USED IN WARM AIR RESEARCH RESIDENCE

Story	Room	Leader		Stacks (or throats)			Registers		
		Dia. in.	Area sq. in.	Size in.	Type	Area sq. in.	Size in.	Free Area sq. in.	Free Area Per Cent of Total
First	Living Room, N.	10	78.5	5½x13	Double	71.5	10x12	83.5	70
	Living Room, S.	10	78.5	5½x13	Double	71.5	10x12	83.5	70
	Hall	12	113.0	7 9/16x14	Single	106.0	12x14	120.5	72
	Dining Room	10	78.5	5½x13	Double	71.5	10x12	83.5	70
	Kitchen	12	113.0	7 x14	Single	98.0	12x14	120.5	72
Second	E. Bedroom	10	78.5	5 x12	Single	60.0	10x12	83.5	70
	S. W. Bedroom	9	64.0	3½x12	Single	42.0	9x12	74.0	69
	Bathroom	8	50.0	3 x10	Double	30.0	8x10	53.0	67
	N. W. Bedroom	10	78.5	5½x13	Double	71.5	10x12	83.5	70
Third	E. Dormitory	8	50.0	3 x10	Single	30.0	8x10	53.0	67
	W. Dormitory	8	50.0	3 x10	Double	30.0	8x10	53.0	67
		Totals							
First			461 5			417.5			
Second			271.0			203.5			
Third			100.0			60.0			
Total			832.5			681.0			

the weather, and that throughout the residence the proportion of glass area is high. Hence the heating problem was typical of residence heating. The heat losses calculated by the standard methods are approximately 119,000 B.t.u. per hour at 0 deg. fahr., and 15 mi. per hour wind velocity.

Heating Plant

A gravity circulating warm-air heating plant was installed, and has been in operation in the residence continuously during each heating season since December, 1924. The heater was of a common cast-iron type, and had a grate area of 2.88 sq. ft. The smoke pipe, 10 in. in diameter and 10 ft. in length, was connected to a 12-in. × 12-in. fireclay-lined flue, which was 35 ft. high. This chimney had 8-in. brick walls, and passed up through the house. A cross damper in the smoke pipe, 3 ft. from the furnace, was used to restrict the draft. The check draft was sealed.

The location of the warm-air registers are shown in Figs. 2, 3, and 4, and details of the piping and registers are given in Table 1. A single cold air return was in use when the data herein presented were obtained. The cold air was returned through a 36-in. × 36-in. square wood grille and 33-in. round duct, from a position in the hall near the main entrance to the residence. The free area of the grille was 800 sq. in. and the duct area 854 sq. in.

The heat pipes and fittings, eleven in number, were of standard commercial sizes and types, no effort being made to obtain streamline flow by the use of special fittings. All pipes were of bare bright tin, except for narrow sealing strips of asbestos paper at the joints, previous tests having demonstrated that asbestos paper covering on bright tin pipes is wasteful of heat.[4] The wall stacks were of mixed construction, some being of double tin with intervening air space, and others of single tin construction. The cross-sectional area of the stacks averaged 70 per cent of the area of the basement heat pipes to which they were connected. Registers were of commercial types and sizes and, in this particular installation, were all of the wall types.

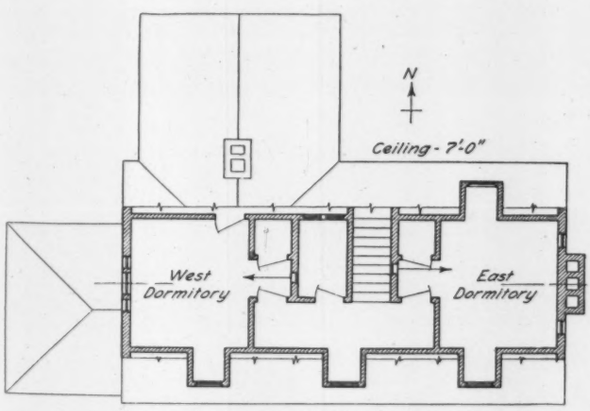

Fig. 4. Third Floor Plan With Location of Warm-air Registers

[4] Emissivity of Heat from Various Surfaces, by V. S. Day, University of Illinois Experiment Station Bulletin No. 117.

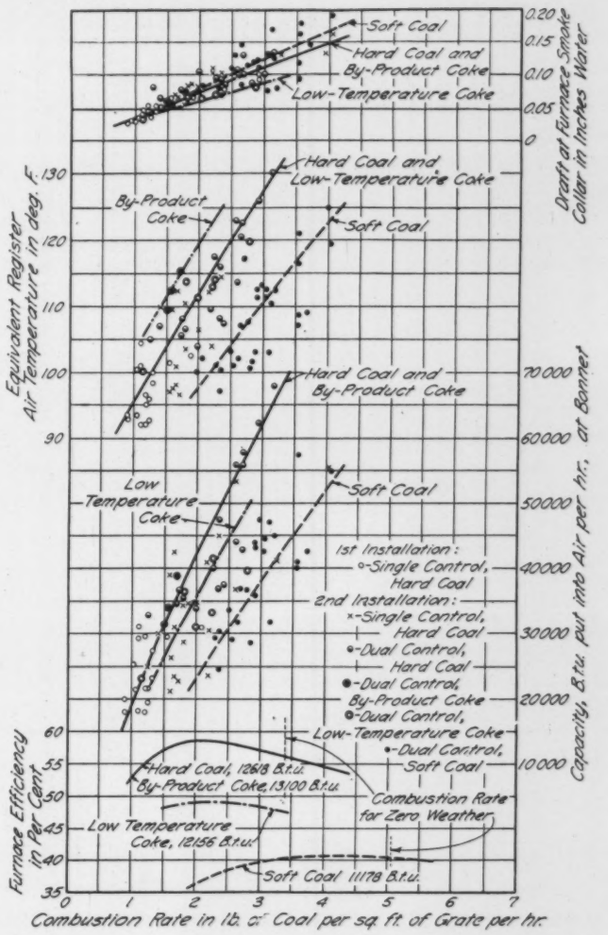
Soft Coal
Hard Coal and By-Product Coke
Low-Temperature Coke
Hard Coal and Low-Temperature Coke
By-Product Coke
Soft Coal
Hard Coal and By-Product Coke
Low Temperature Coke
Soft Coal
1st Installation:
o-Single Control, Hard Coal
2nd Installation:
×-Single Control, Hard Coal
o-Dual Control, Hard Coal
●-Dual Control, By-Product Coke
⊙-Dual Control, Low-Temperature Coke
•-Dual Control, Soft Coal
Hard Coal, 12618 B.t.u.
By-Product Coke, 13100 B.t.u.
Low Temperature Coke, 12156 B.t.u.
Soft Coal 11178 B.t.u.
Combustion Rate for Zero Weather
Equivalent Register Air Temperature in deg. F.
Furnace Efficiency in Per Cent
Capacity, B.t.u. put into Air per hr. at Bonnet
Draft at Furnace Smoke Collar in Inches Water
Combustion Rate in lb. of Coal per sq. ft. of Grate per hr.

Fig. 5. Performance Curves for Hard and Soft Coal and Coke

It has been the object in this description of the research residence and the heating plant to show that both were standard rather than special, and that, therefore, the data which follow are such as might be obtained in any well designed warm-air heating plant.

Furnace Performance with Hard and Soft Coal

The performance of the plant with anthracite coal, low-temperature and by-product coke, and bituminous coal is shown by the curves in Fig. 5.

With anthracite coal, the maximum efficiency of the furnace proper was 58.5 per cent, and the corresponding combustion rate was approximately 2.5 lb. coal burned per square foot of grate per hour. With soft coal, the maximum efficiency was only 41 per cent and occurred at a combustion rate of over 4 lb.

Of the heat in the air at the furnace bonnet (which at a maximum was 58.5 per cent of the heat of the fuel burned), only 75 per cent was delivered at the registers. This is shown by the curves of Fig. 6. This loss of heat between the bonnet and registers consists of heat loss from the leaders in the basement and from the stacks in the walls, and takes place by both radiation and convection. It has the effect of reducing the efficiency of the system as a whole, as shown in the lower curves of Fig. 6.

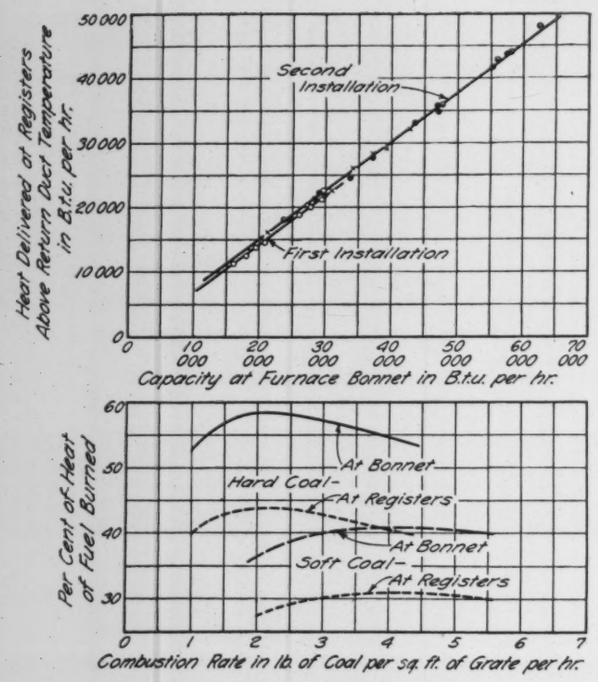

FIG. 6. LEADER AND STACK LOSSES, AND EFFICIENCY AS OF REGISTERS

Here the efficiencies as of the bonnet and as of the registers, for both hard and soft coal, are shown. With hard coal, it is indicated that whereas 59 per cent of the heat of the fuel was available at the bonnet only 44 per cent finally was delivered at the registers. For soft coal, the corresponding values were 41 per cent available at the bonnet and 31 per cent delivered at the registers.

In designing the heating system for the residence, a register air temperature of 175 deg. fahr., and a corresponding combustion rate of 7.5 lb. coal per square foot of grate per hour in zero weather were used. However, the data taken over a period of two winters indicates that in spite of a furnace efficiency of less than 60 per cent, and a considerable loss between the bonnet and registers, the plant operated at a 135 deg. register temperature and a 3.5 lb. combustion rate, as shown by Fig. 7.

The design was based on the assumption that the only heat available to supply the heat loss from the house was the heat delivered at the registers. It is apparent from the data obtained that this was not the case for the house was satisfactorily heated at much lower register air temperatures and combustion rates than those assumed. The difference between the heat appearing at the bonnet and that delivered at the registers was not a real loss. The loss from the stacks served to warm the walls and to make up a heat loss that otherwise would have had to have been supplied by the air in the rooms, and the radiation and convection from the leader pipes was available for warming the first story floors. Any heat loss between the bonnet and registers or from the furnace casing and smoke pipe must of necessity remain in the house. The heat may not be utilized to the best advantage, but it is by no means a total loss.

In the same way the heat loss from an inside chimney is available for heating the house. For an indication of the magnitude of the heat available within the residence from the smokepipe and chimney see the flue gas temperature curves of Fig. 8 and the total heat loss curves of Fig. 9. In the former figure, the flue gas temperature drop in zero weather is (570 — 190) = 380 deg. for hard coal, and in the latter figure, the difference in the total heat loss at the furnace and the top of chimney is (20.5 — 7.5) = 13.0 per cent of the heat in fuel.

Over-all Efficiency of Residence and Heating System

The loss of heat from the top of the chimney, when an inside chimney is used, is the only ultimate loss of heat from the house. By subtracting from 100 the percentage losses at the top of the chimney, as shown by Fig. 9, the over-all efficiency of the house and heating installation may be determined. This has been done, and the efficiency curves are shown in Fig. 10. When hard coal was fired, the over-all efficiency ranged from 92 to 97 per cent, averaging 95 per cent for average weather. With soft coal, the over-all efficiency averaged 75 per cent.

These over-all efficiencies have also been determined by another method, consisting of an accurate calculation of the heat loss of the building and a comparison of this loss with the heat generated on the grate. A few points based on this method of estimating over-all house efficiencies are shown plotted in Fig. 10 for hard-coal and soft-coal operation. Each point represents the average of several daily tests with each fuel; and the agreement be-

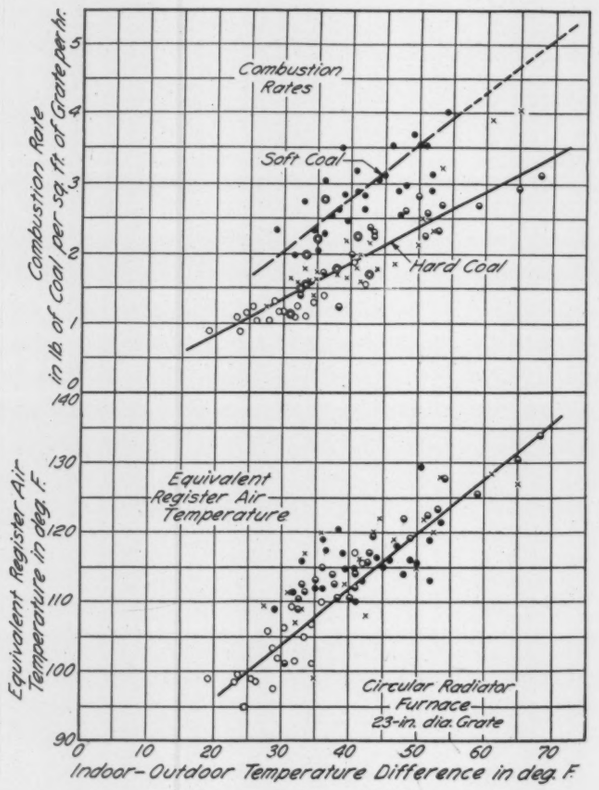

FIG. 7. REGISTER AIR TEMPERATURE AND COMBUSTION RATE CURVES FOR VARIOUS OUTDOOR TEMPERATURES

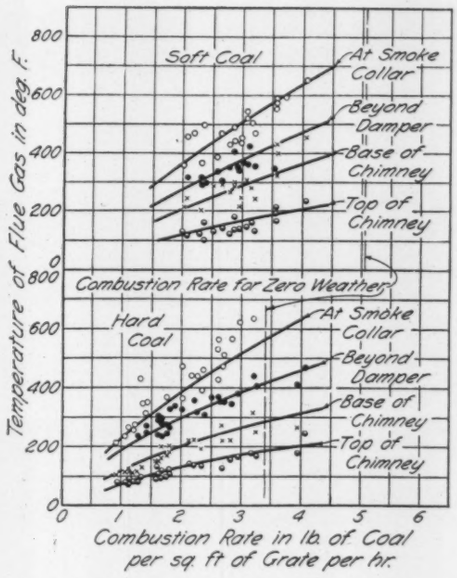

FIG. 8. FLUE-GAS TEMPERATURES FOR HARD AND SOFT COAL

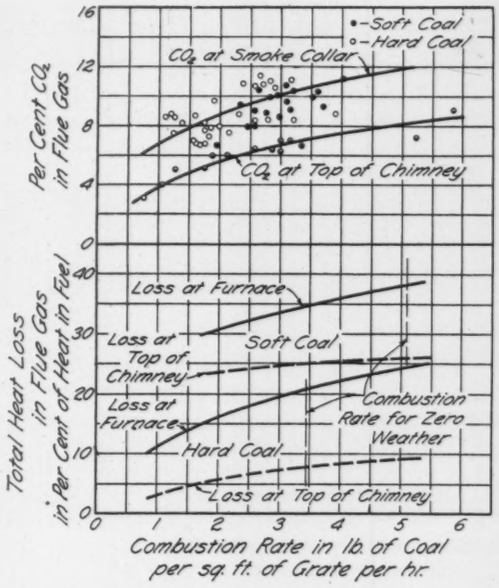
•-Soft Coal
o-Hard Coal
CO_2 at Smoke Collar
CO_2 at Top of Chimney
Per Cent CO_2 in Flue Gas
Loss at Furnace
Loss at Top of Chimney
Soft Coal
Combustion Rate for Zero Weather
Hard Coal
Loss at Top of Chimney
Total Heat Loss in Flue Gas in Per Cent of Heat in Fuel
Combustion Rate in lb. of Coal per sq. ft. of Grate per hr.

FIG. 9. FLUE-GAS LOSSES FOR HARD AND SOFT COAL

tween the points and the curves indicates that the curves are a fair approximation of the over-all thermal efficiency of the house.

Close agreement between the curves and the over-all house efficiency for any one daily test cannot be expected, since it is quite impossible to make a correct estimate of the exact heating load on any given day. Averages for several days, based on estimated daily heat losses for similar days, are much more reliable values, and were, therefore, used in Fig. 10.

Bearing in mind that the residence was heated to 70 deg. fahr. with high over-all house efficiencies but with low register air temperatures and register efficiencies, it is evident that a large percentage of the heat found its way into the rooms of the house by indirect paths such as through the floors and walls and from the chimney surfaces. An estimate of this indirect heat is shown in Table 2. With either hard or soft coal, the indirect heat exceeded in amount the heat delivered at the registers.

While the indirect heat exceeded the heat delivered at the registers, its distribution was such that the house was uniformly heated. The average temperature at the breathing level for the first story based on 10 tests, was 70.7 deg. fahr. For the second story the average was 70.1 deg. fahr., and for the third story it was 67.0 deg. The average outdoor temperature for the 10 tests was 29.0. The maximum deviations from the average occurred in the S.W. bedroom, where the breathing level temperature was 73.0 deg. fahr. and in the N.W. bedroom where it was 66.4 deg. fahr. The low temperature in the N.W. bedroom was caused by an unfloored attic space above the room. This condition was later corrected by nailing two layers of ½-in. quilt insulation on top of the floor joists in the attic. When this was done, the breathing level temperature rose to 69.7 deg. fahr. Hence, it is evident that the heat delivered at the registers was ample to serve as a control and to produce uniform temperatures throughout the house.

TABLE 2. PERCENTAGE OF HEAT DISTRIBUTION THROUGH RESEARCH RESIDENCE

FUEL USED	HARD COAL	SOFT COAL
Overall house efficiency, per cent of heat of fuel.....	94	75
Maximum efficiency at registers, per cent of heat of fuel.....	44	31
Difference, or per cent of heat of fuel distributed through Residence by indirect paths.....	50	44

Performance on Hard and Soft Coal

The results indicate a considerable difference in plant performance between hard and soft coal. From the general performance curves of Fig. 5 it may be noted that for a given combustion rate, soft coal gave a materially lower efficiency, capacity, and equivalent register air temperature than hard coal. Thus soft coal gave an over-all house efficiency of only 75 per cent as compared with hard coal efficiencies of over 90 per cent. An analysis of the data obtained while burning the two fuels indicates the cause of this difference.

The flue gas loss consists of a sensible heat loss and a loss resulting from unburned combustible constituents. Figs. 8 and 9 show the comparison of flue-gas temperatures and heat

losses for the two fuels. For each kind of fuel four curves are shown representing the temperature of the flue gases at four points in their passage through smokepipe and chimney. The curves show that at a given combustion rate the flue-gas temperatures were almost the same for the two fuels. Thus at a combustion rate of 3.0 lb. the curves show the following temperatures:

	Hard Coal	Soft Coal
Temperature at furnace, deg. fahr.....	520	510
Temperature at top of chimney, deg. fahr.	175	170

(Temperature at top of chimney actually measured in chimney at roof line.)

Furthermore, it should be noted that at the same combustion rate with hard and soft coal, the CO_2 percentage was the same in both cases. Therefore, the excess air and the weight of flue gas per pound of coal were approximately the same for the two cases. Hence at a given combustion rate, since the weight and temperature of the flue gas was the same for the two fuels, the sensible heat loss must have been the same. It therefore appears that the difference between the losses with hard coal and soft coal must have been largely due to unburned combustible in the flue gases.

Analyses of the flue gas showed no hydrogen or carbon monoxide for hard coal, but for soft coal they indicated 2 per cent free hydrogen and 1 per cent carbon monoxide. This amount of free hydrogen represented a loss of approximately 1100 B.t.u. per pound of soft coal burned, and the 1 per cent carbon monoxide represented a loss of approximately 500 B.t.u. per pound of coal burned. In addition there was more hydrogen in the soft coal than in the hard coal and hence the loss due to water vapor in the flue gas was greater. The total of these losses amounted to about 15 per cent of the heat value of the fuel.

This 15 per cent loss resulted in higher combustion rates with soft coal for given indoor-outdoor temperature differences than those obtained with hard coal. A contributing factor was the difference in heat value of the two fuels; 11,178 B.t.u. for the soft coal as against 12,618 B.t.u. for the hard coal. The net result as shown by Fig. 7 was a 5-lb. combustion rate with soft coal for a 70 deg. indoor-outdoor difference, as compared with a 3.5 lb. combustion rate with hard coal.

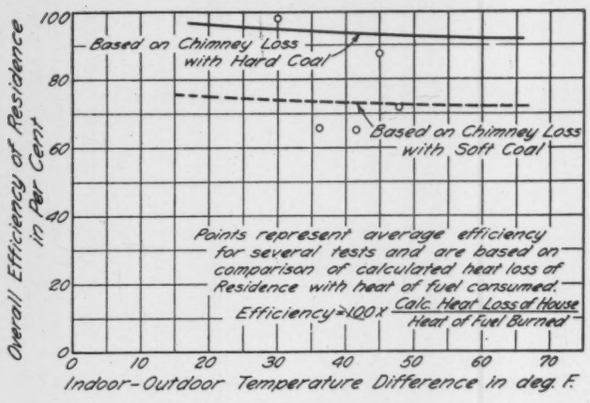
Overall Efficiency of Residence in Per Cent
100
80
60
40
20
0
Based on Chimney Loss with Hard Coal
Based on Chimney Loss with Soft Coal
Points represent average efficiency for several tests and are based on comparison of calculated heat loss of Residence with heat of fuel consumed.
Efficiency = 100 x Calc. Heat Loss of House / Heat of Fuel Burned
0 10 20 30 40 50 60 70
Indoor-Outdoor Temperature Difference in deg. F.

Fig. 10. Over-all Efficiency of Residence

It has been indicated that at a given combustion rate the sensible heat loss in the flue gas was approximately the same for both hard and soft coal. But for soft coal the loss due to unburned combustible and increased water vapor together with the lower heat value of the soft coal resulted in a considerable increase in the combustion rate for a given indoor-outdoor difference. This increase was reflected in a higher flue gas temperature, as shown in Fig. 8, where the combustion rate for zero weather is indicated. A higher flue gas temperature represented a greater sensible heat loss, so that for a given indoor-outdoor difference the soft coal also had a greater sensible heat loss in the flue gases than the hard coal. This, however, was not a primary effect, but was brought about directly from chemical losses in the flue gases.

The combined effect of the 15 per cent chemical loss and the increased sensible heat loss in the flue gas accounts for the 20 per cent decrease in over-all house efficiency when burning soft coal. The loss is entirely in the flue gas and could not possibly be available for heating the house.

Conclusions

The practice of comparing heating plants on the basis of boiler or furnace efficiency may be misleading. The efficiency of the heating unit and distributing system is important from the standpoint of delivering heat at desired points, but in a self contained system such as a residence, the vagrant heat by no means constitutes a dead loss. It raises the heating efficiency of the system as a whole, and generally serves to warm floors and walls where heat is desirable. When the over-all house efficiency is considered, the actual heating unit efficiency becomes less important while combustion efficiency becomes more important.

The over-all effect should be the final criterion for judging the performance of any heating system and the data illustrate that while a study of the performance of the component parts of the system may be valuable in determining the possibility of improvement in the design of such parts, conclusions in regard to the performance of the system as a whole based on a study of the component parts alone may be very misleading.

JUNE 26-28, 1929
A. S. H. & V. E. SEMI-ANNUAL MEETING
Bigwin Inn, Lake-of-Bays, Ontario, Canada

Pipe Sizes for Hot Water Heating Systems

The results of co-operative research between the A. S. H. V. E. and the Texas Engineering Experiment Station

By F. E. Giesecke[1] (Member) and Elmer G. Smith[2] (Non-Member), College Station, Texas

Introduction

THE object of this investigation is to secure data which may serve as a basis for tables and graphs from which pipe sizes for hot water heating systems may be easily determined.

The heating systems studied were of the gravity flow type with under-foot main and of such size as to be suitable for residences of ordinary size.

Three varieties were studied, namely:

(a) A system with single main, as shown in Fig. 1.

(b) A system with double main and direct return, as shown in Fig. 2.

(c) A system with double main and reversed return, as shown in Fig. 3.

In each case the heater was located about 3 ft. 6 in. below the mains, the water was heated by means of steam and all pipes were bare. The temperature of the water was measured by means of ordinary mercury thermometers passing through rubber stoppers so that the thermometer bulb was immersed in the water.

The outstanding result of this investigation is the discovery that, for the type of system studied, the pressure heads produced by the individual radiators with their connecting pipe lines may be so large when compared with the pressure head produced by the heater with its main flow and return risers that they may interfere seriously with the proper circulation of the water in a gravity flow system of the type used in this investigation, if the pipe system has not been accurately designed and built.

These disturbing effects of the radiator pressure heads are particularly active during the heating-up periods of the operation of the heating systems. For example, in the system shown in Fig. 4, the pressure head produced by the heater tends to produce flow through the system in the directions shown by the straight line arrows. The pressure head produced by Radiator 1 tends to produce flow through the system in the directions shown by the wavy line arrows. The hot water reaches Radiator 1 before it reaches Radiator 2, and the pressure head of Radiator 1 becomes active as soon as its flow riser is filled with warm water. In the section between

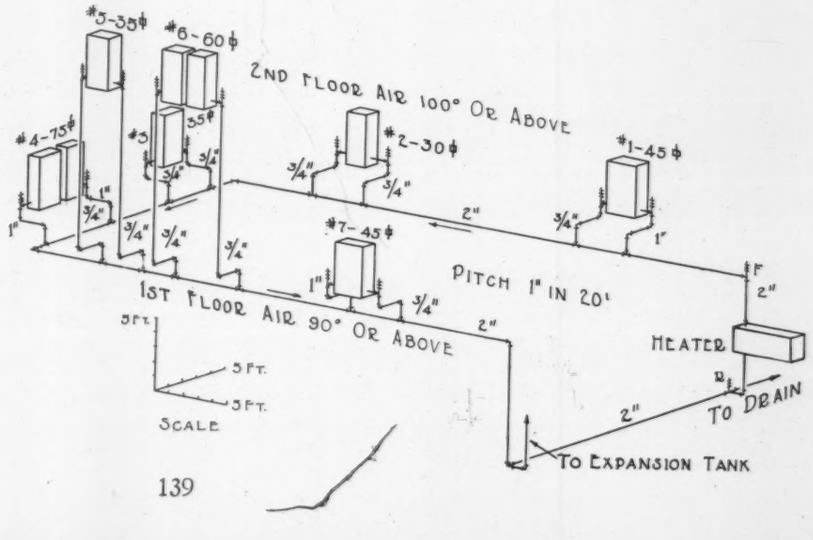

FIG. 1. EXPERIMENTAL INSTALLATION OF A ONE-PIPE SYSTEM

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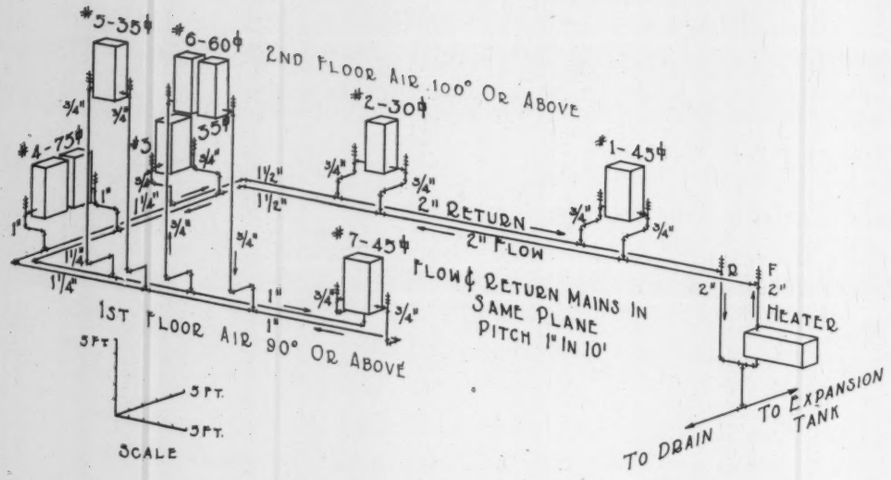


FIG. 2. EXPERIMENTAL INSTALLATION OF A TWO-PIPE DIRECT-RETURN SYSTEM

the heater and Radiator 1, the two pressure heads supplement each other, but in the sections between Radiator 1 and Radiator 2, they oppose each other. When the pressure head, in this section, produced by Radiator 1 is larger than that produced there by the heater, the circulation through Radiator 2 will be *reversed,* and Radiator 2 will be supplied with water that has been cooled by flowing through Radiator 1. If the pressure head produced by Radiator 1 is not large enough to "reverse" the flow through Radiator 2 it may be large enough to retard the flow through that radiator materially.

The opposing pressure heads produced by intermediate radiators in two-pipe direct return systems may be largely responsible for the sluggish flow through the radiator farthest from the heater.

The *reversal* of flow through Radiators 5, 6, and 7 in the two-pipe direct return system is clearly shown in Fig. 21. However, this *reversal* was also found in Radiators 6 and 7 in the two-pipe reversed return system (the so-called, non-short-circuiting system) as shown in Fig. 15.

To prevent the *reversal* of flow in all parts of the heating system, the installation must be designed and executed so that at all points of every circuit the available pressure head will be of the direction necessary to produce the flow desired by the designing engineer.

The above explanation may be clearer if the heater and radiators are replaced by circulating pumps as shown in Fig. 5, or by electric generators, as shown in Fig. 6, and, in that case, electric currents substituted for streams of water.

To design heating systems of the types studied in this investigation it is evidently desirable to have the pressure head produced by the heater as large as possible and the pressure heads produced by the radiators as small as possible. These results can be attained in part by placing the flow and return mains as high as possible above the heater and as near as possible to the radiators, and by attaching the flow and return risers to the bottom tappings of the radiators.

Experimental Installation and Operation

This investigation was planned and is being conducted in co-operation with H. M. Hart, Chairman of Committee on Pipe Sizes for Heating Systems, AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

The purpose of the investigation is to secure data upon which simple tables and rules can be based which may be used by steamfitters in designing and planning hot-water heating systems.

Since the correct design of a large hot-water heating system is not very simple, it was decided to ex-

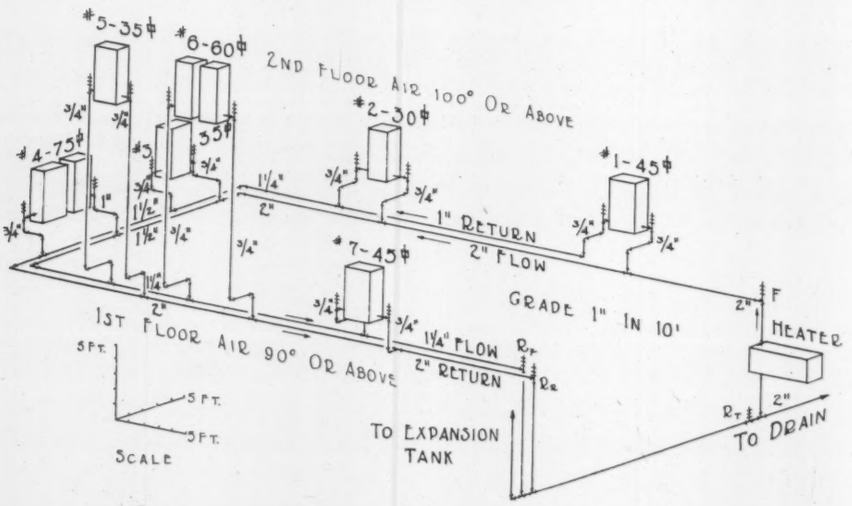


FIG. 3. EXPERIMENTAL INSTALLATION OF A TWO-PIPE REVERSED-RETURN SYSTEM

periment first with a small system such as might be used in the ordinary one-family residence. It was assumed that it would be possible to prepare tables by which the ordinary one-pipe heating system could be designed, but since a properly operating two-pipe

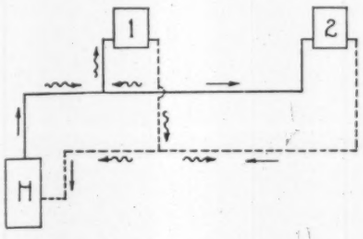


FIG. 4. DIAGRAM ILLUSTRATING HOW THE PRESSURE HEAD GENERATED BY ONE RADIATOR MAY CAUSE A REVERSAL OF FLOW IN SOME OTHER RADIATOR

system possesses advantages over the one-pipe system, it was decided to experiment with a two-pipe system. Mr. Hart preferred the two-pipe direct return to the two-pipe reversed return. One objection to the two-pipe reversed return was that the flow and return mains in the basement generally

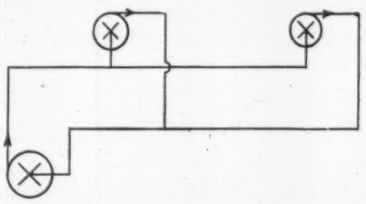


FIG. 5. CIRCUIT ANALOGOUS TO THAT OF FIG. 4, THE HEATER AND RADIATORS BEING REPLACED BY CENTRIFUGAL PUMPS

slope in opposite directions. This makes such a system a little more difficult to install and causes it to present a less attractive appearance than is the case with a direct return system. However, since many engineers believe that a system with a reversed return is less apt to *short circuit* than a system with direct return, it was believed that such a system would adapt itself more easily to design by means of tables or rules of thumb than would a direct return system. For this reason it was decided to begin the experiment with a reversed return system. It was felt that the objection to having the two mains sloping in opposite directions could be easily overcome by pitching both mains downward and connecting the far end of the flow main to the return, as shown in Fig. 3, so as to permit complete draining of the system when desired.

To arrive at some basis for an empirical table of pipe sizes, it was assumed that the distance from the center of the heater to the center of the flow and return mains would be about 3 ft. 9 in. and that the temperature drop through the system would be about 30 deg., and that the total equivalent length of circuit of any radiator would be about 150 ft. For these

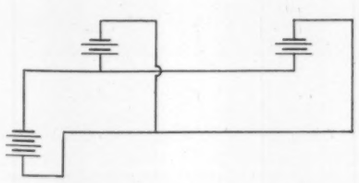


FIG. 6. ELECTRICAL CIRCUIT ANALOGOUS TO THAT OF FIG. 4, THE HEATER AND RADIATORS BEING REPLACED BY BATTERIES

conditions the total available pressure head[3] would be about 500 mil inches of water column and the permissible friction head in the pipe lines, about 3½ mil inches per foot.

[3] These values were taken from the diagrams published in The 1929 Guide and in the Design of Gravity Circulation Water Heating Systems by F. E. Giesecke.

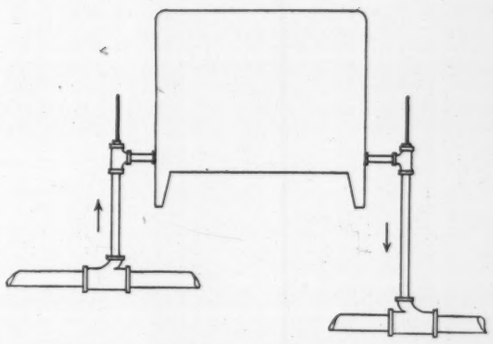


FIG. 7. METHOD OF INSTALLING LONG SWEEP TEES IN THE REVERSED-RETURN SYSTEM

For this condition the following table of pipe sizes[3] would apply:

Pipe Size	B.t.u.
¾	4,200
1	7,500
1¼	16,000
1½	24,000
2	44,000
2½	75,000

Using this table, the pipe sizes shown for the mains in Fig. 3 were selected.

No pipe smaller than ¾ in. was used and, consequently, all risers were made ¾ in. or larger.

In all tests, a heat exchanger was used as a heater and the water heated by means of steam having a pressure of 25 lb. or less. The installations were made in a building in which the air temperature ranged from 90 deg. to 110 deg. during the tests.

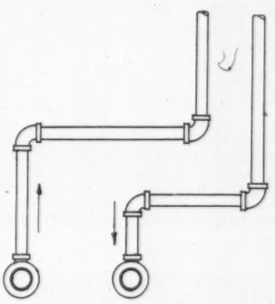


FIG. 8. RISER CONNECTIONS TO MAINS AS ORIGINALLY MADE

The system shown in Fig. 3, as first installed, had four radiators, Nos. 1, 2, 3, and 4, on the first floor, and two radiators, Nos. 5 and 6, on the second floor. Radiator No. 7, as shown in the figure, was not at first installed.

When this system was put into operation Radiators 1 to 4 operated correctly, but Radiators 5 and 6 did not. During every test run the flow of water was reversed either through Radiator No. 5 or through Radiator No. 6. Fig. 15 illustrates the records secured during one of these unsatisfactory tests. The flow was never in the same direction through both radiators at the same time; sometimes it would be direct through No. 5 and reversed through No. 6, and at other times, reversed through No. 5, and direct through No. 6.

In order to remedy this condition, the following changes were made: (1) The ordinary tees connecting the risers of Radiators 5 and 6 to the mains were replaced by long sweep tees, as shown in Fig. 7, in

such a way that the friction in the circuit was materially increased whenever the direction of the flow was reversed.

This change had practically no effect; the flow continued to reverse in one of the two radiators, in spite of the additional friction caused by this reversal in the long sweep tees.

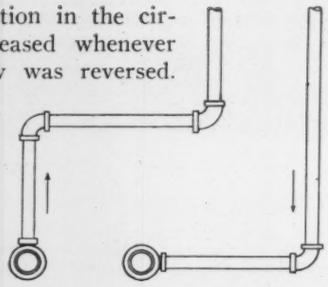


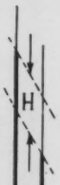
FIG. 9. RISER CONNECTIONS TO MAINS AS MADE IN AN ATTEMPT TO PREVENT REVERSED RADIATOR FLOW

(2) The riser connections to the main were changed from that shown in Fig. 8 to those in Fig. 9. This change also had no apparent affect.

While the changes enumerated above were not effective, it seemed at times as if they were helping considerably, indicating that the direction of flow was unstable, and might be reversed by comparatively minor influences.

(3) Up to this time the flow and return risers had been connected to the lower tappings of the radiators; as it seemed that the direction of the flow was unstable and that a small difference in pressure head or in friction head might serve to reverse the flow or to prevent reversal, the connections of the flow risers were changed from the lower tappings to the upper tappings of the radiators so that if a reversal of flow through any one radiator occurred, the hot water would have to enter that radiator through the lower tapping and the cooler water leave through the upper tapping. This change was also ineffective, and, in fact, it made conditions worse, as it resulted in a reversal of flow not only in Radiator No. 6, but also in Radiator No. 3.

At this time a careful study was made of the pressure heads producing flow and the friction heads resisting flow in the several parts of the system, and especially in comparison with the conditions that exist in an electrical installation in which the heater and the several radiators are replaced by batteries which furnish the pressure heads, and the pipe lines are replaced by wires which furnish friction heads and it was decided to introduce sufficient friction in each radiator connection to balance the pressure head produced by that particular radiator and also the pressure head available at that radiator of the total pressure head produced by the heater—in other words, to design the circuit for every radiator so that the friction head in that circuit is exactly equal to the pressure head for that circuit.



Since this could not be done without using pipes smaller than ¾ in. for the radiator connections, it was decided to use one or more circular orifices, installed in unions in the radiator connections. For this purpose copper sheets, having a thickness of about .025 in., with openings of respectively ¼ in., 5/16 in., and ⅜ in. were secured and the friction heads produced by these orifices in ¾ in. pipes were determined.

To determine the friction head caused by a circular orifice in a thin metal plate placed in a union in a ¾ in. pipe, the apparatus shown in Fig. 10 was constructed in such a way that there were 20 unions separated from each other by 6 in. nipples, the pipe line doubling back on itself so that the two glass manometer tubes were near each other to facilitate the measurement of the difference in elevation, *H*, of the surface of the water in the two tubes. This difference in elevation, *H*, is the head lost in the path from *A* to *B*. The larger portion of this loss of head is produced by the 20 orifices and the remainder by the pipe line, *AB*.

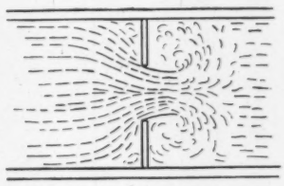


FIG. 11.—FLOW OF WATER THROUGH A SUBMERGED ORIFICE

To arrive at an approximate value of the loss of head caused by one orifice, let us assume that the water is flowing along the ¾ in. pipe with a velocity of 2 in. per second, and that it is forced to flow through a circular orifice and that, in flowing through the orifice, the stream lines converge, as indicated in Fig. 11, and as is known to be the case when the discharge through the orifice is into the air, in which case, the area of the most contracted portion of the stream is about 62 per cent of that of the area of the orifice. When the stream of water is discharged into a body of water instead of into air it may be checked before its area can contract materially. Assuming that no contraction takes place, the maximum velocities at the three respective orifices will be 21.7, 13.87, and 9.66 in. per second, when the velocity of the water in the ¾ in. pipe is 2 in. per second. The respective heads required to produce these increases in velocity are 604, 240, and 115 mil in.

Assuming that the energy required to produce these velocity heads is transformed entirely into heat (which, in these cases, would elevate the temperature of the water less than 1/10,000 deg. fahr.) these heads of 604, 240, and 115 mil in., respectively, would be the friction heads added to the radiator circuits by introducing a ¼, 5/16, or ⅜ in. orifice into a ¾ in. line when the water has a velocity of 2 in. per second in the ¾ in. line.

If the above reasoning is correct, the friction heads caused by such orifices will be practically independent of the temperature of the water, because, in these cases, the losses of head are not caused by internal fluid friction, but by transformation of kinetic energy into heat.

The results of the experimental determinations are shown in Figs. 12 and 13. The friction head

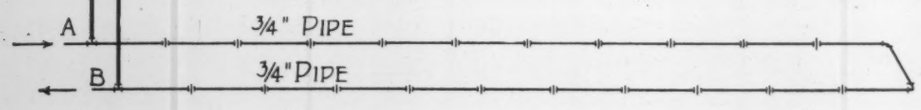


FIG. 10. APPARATUS FOR DETERMINING THE FRICTION HEAD OF AN ORIFICE

caused by the pipe line *AB* (without the 20 orifice plates) is represented by the line near the bottom of the diagram. The friction heads caused by the pipe line *AB* plus the 20 orifices are shown by the three other lines which represent respectively the ⅜ in., 5/16 in., and ¼ in. orifices.

A comparison of these four lines shows that the friction head of the line *AB* without the orifices is so small when compared with the friction heads of the pipe line with the orifices that it may practically be neglected.

A comparison of the values shown by Fig. 12, which were secured with water having a temperature of 88 to 90 deg., with the values shown by Fig. 13, which were secured with water having a temperature of 140 to 164 deg. fahr., shows that the two sets of values are practically identical and that the friction head caused by an orifice is practically independent of the temperature of the water, as suggested above.

With the data of Fig. 13 as a basis, the curves of Fig. 14 were prepared for use in the design of hot-water heating systems.

Referring to Fig. 14, it will be seen that the friction heads of a ¼ in., 5/16 in., and ⅜ in. orifice, for a velocity of 2 in. per second in the ¾ in pipe are, respectively, 1,130, 400, and 170 mil in., or about 88 per cent, 66 per cent, and 46 per cent, respectively, more than those calculated on the assumption that there is no contraction of the stream flowing through the orifice. If these increased friction heads are to

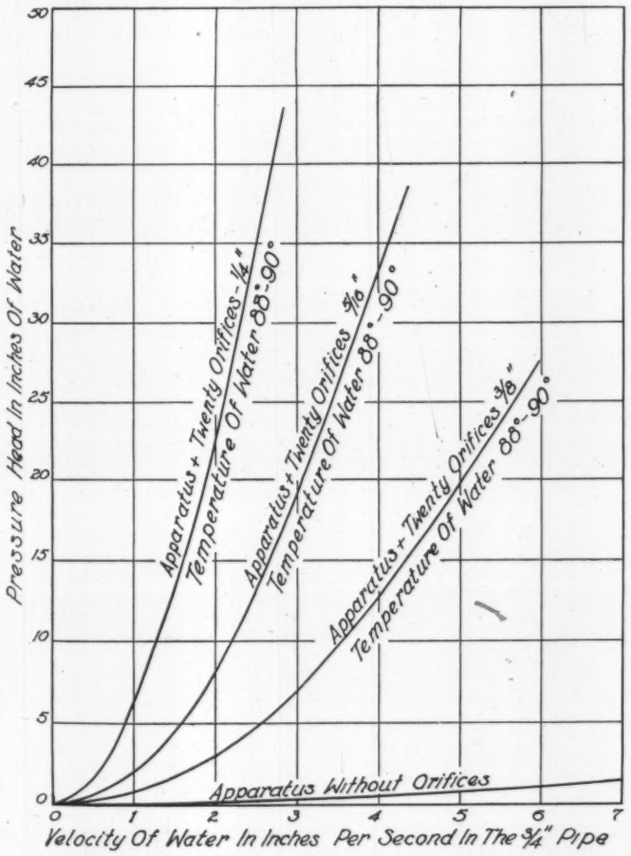

Pressure Head In Inches Of Water
Velocity Of Water In Inches Per Second In The ¾" Pipe
Apparatus + Twenty Orifices - ¼" Temperature Of Water 88°-90°
Apparatus + Twenty Orifices 5/16" Temperature Of Water 88°-90°
Apparatus + Twenty Orifices ⅜" Temperature Of Water 88°-90°
Apparatus Without Orifices

Fig. 12. Warm Water Friction Heads of the Apparatus Depicted in Fig. 10

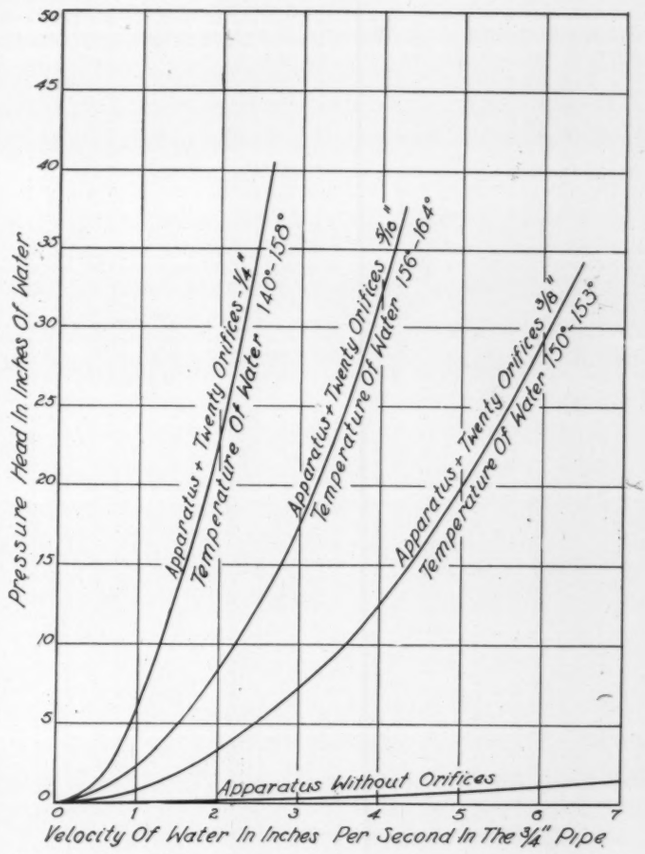

Pressure Head In Inches Of Water
Velocity Of Water In Inches Per Second In The ¾" Pipe
Apparatus + Twenty Orifices - ¼" Temperature Of Water 140°-158°
Apparatus + Twenty Orifices 5/16" Temperature Of Water 156°-164°
Apparatus + Twenty Orifices ⅜" Temperature Of Water 150°-153°
Apparatus Without Orifices

Fig. 13. Hot Water Friction Heads of the Apparatus Depicted in Fig. 10

be accounted for by a contraction of the stream through the orifice, the respective contractions in area, must be about 73 per cent, 77 per cent, and 82 per cent.

Having determined the friction heads caused by these orifice resistors, it is comparatively easy to determine which resistors and how many must be inserted in any one of the radiator circuits in order that the friction head in that circuit may be equal to the pressure head available for that circuit when the system is operating at the rate for which it was designed.

This was done and a very satisfactory operation of the system was secured. The results of one of the experimental runs are shown in Fig. 16. It is evident, from this graph, that all radiators were operating in the right direction, that the temperature drop through each radiator was about 25 deg. fahr., and that the water entering Radiator 7 was almost 20 deg. cooler than that entering Radiator 1.

This excessive cooling of the water before it reaches the last radiator emphasizes the importance of covering the mains, or at least of covering the flow main.

Comparing the operation of the system as shown by Fig. 15, when the system had been very crudely designed according to approximate rules for pipe sizes, with the operation of the same system as shown by Fig. 16, when the design of the system had been improved by adding enough resistance to the several

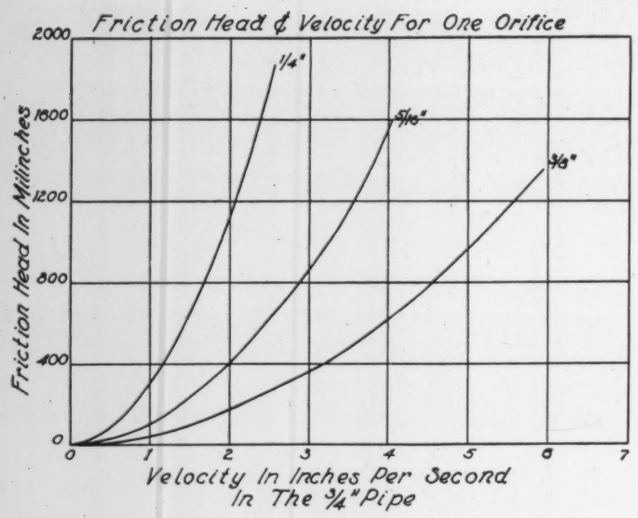


FIG. 14. FRICTION HEADS OF ORIFICES PLACED IN ¾ INCH UNIONS

radiator circuits so that in every case the friction head for the circuit was equal to the pressure head for that circuit, will suggest that for a heating system of the type under discussion it is impossible to prepare a set of tables from which pipe sizes can be selected in such a way that the system will function correctly, without including also a set of tables of resistors to supplement the table of pipe sizes, unless the pipe sizes for the mains are unduly large.

It may be possible to secure a radiator valve which will perform the functions of both the orifice resistor and of the radiator valve.

The calculations relating to the use of orifice resistors, mentioned above, are explained in detail in the discussion of the two-pipe direct-return system.

The second experimental installation was the one-pipe system, shown in Fig. 1. The operation of this system was entirely satisfactory. Fig. 17 shows one of the sets of results secured with the one-pipe system. Fig. 18 shows the results secured with the same system after additional friction heads had been introduced in the several radiator circuits by the addition of orifice resistors to the several risers as tabulated in Fig. 18. The effect of the resistors is to retard the flow of the water through the radiator and thereby to increase the temperature drop through the radiator. For example, in the run recorded in Fig. 17, the temperature drop through Radiator 2 is from 186 deg. to 169 deg., or 17 deg., whereas, with the use of the resistors, the temperature drop through the same radiator is from 195 deg. to 158 deg., or 27 deg., as shown in Fig. 18.

Fig. 17 shows clearly that the average temperature of the water in the radiators of a one-pipe system decreases as the distance of the radiator from the heater increases. Consequently, to secure a correct installation it is necessary to base the size of the radiator not only upon the number of B.t.u. which the radiator is to dissipate, but also on the average temperature of the water in the radiator.

FIG. 15. RECORD OF STARTING CONDITIONS FOR THE REVERSED-RETURN SYSTEM WITHOUT RESISTORS

For the installation described herein, the main was not covered because it was felt that in most residences it is desirable to have the basement heated by the main and without the installation of basement radiators. When the basement need not be heated, the main should be covered to reduce the cooling of the water before it reaches the radiators.

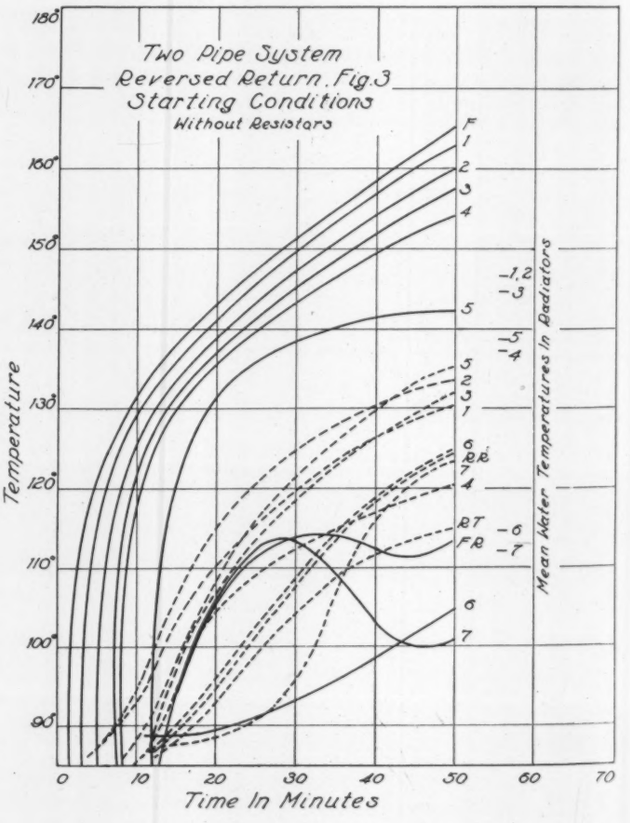
TABLE 1. CAPACITIES IN 1,000 B.T.U. OF MAINS FOR ONE-PIPE SYSTEMS FOR A TEMPERATURE DROP OF 35 DEG. AND A HEAD OF 3 FT. 6 IN.*

LENGTH OF HORIZONTAL MAINS	PIPE SIZES—INCHES							
	1½	2	2½	3	3½	4	5	6
50	37	68	98	171	245	327	580	888
75	32	59	87	151	222	298	527	818
100	28	53	79	138	204	278	487	774
125	26	48	73	129	191	261	460	736
150	23	45	68	121	179	245	437	700
175	22	42	65	114	169	231	415	670
200	21	40	61	107	158	216	394	638
225	20	38	58	101	149	203	374	608
250	19	36	55	95	140	190	354	580

* If the head is more than 3 ft. 6 in., the values given in this table may be increased.

A one-pipe system should be designed so that the drop in temperature through the system will be as small as practicable. This can be accomplished, in part, by using a large main and by covering the main.

The operation of the one-pipe system is so simple and so positive that it is comparatively easy to design and to install such a system, and it seems that it should be possible to prepare tables according to



which pipe sizes and radiators can be determined with sufficient accuracy.

The following sets of tables and rules are proposed for this purpose.

Table 1 is based on a temperature drop of 35 deg. through the system. Table 2 is based on a temperature drop of 25 deg.

Both tables are based on a head of 3 ft., 6 in.; i. e.,

TABLE 2. CAPACITIES IN 1,000 B.T.U. OF MAINS FOR ONE-PIPE SYSTEMS FOR A DROP IN TEMPERATURE OF 25 DEG. AND A HEAD OF 3 FT. 6 IN.*

LENGTH OF HORIZONTAL MAINS	PIPE SIZES—INCHES						
	2	2½	3	3½	4	5	6
50	41	59	100	140	195	346	552
75	35	51	90	130	179	320	500
100	31	48	83	121	165	293	450
125	30	44	75	113	153	280	425
150	27	40	70	104	143	265	405
175	25	38	66	98	136	252	390
200	24	35	63	93	130	239	377
225	23	34	61	90	125	225	367
250	22	33	60	88	120	223	358

* If the head is more than 3 ft. 6 in., the values given in this table may be increased.

on a vertical distance of 3 ft., 6 in. from the main to the center of the heater. If the distance is greater, the system will function better than indicated by the tables.

Both tables are based on the assumption that the main is covered. If the main is bare, the farther radiators will not be as efficient as the tables imply.

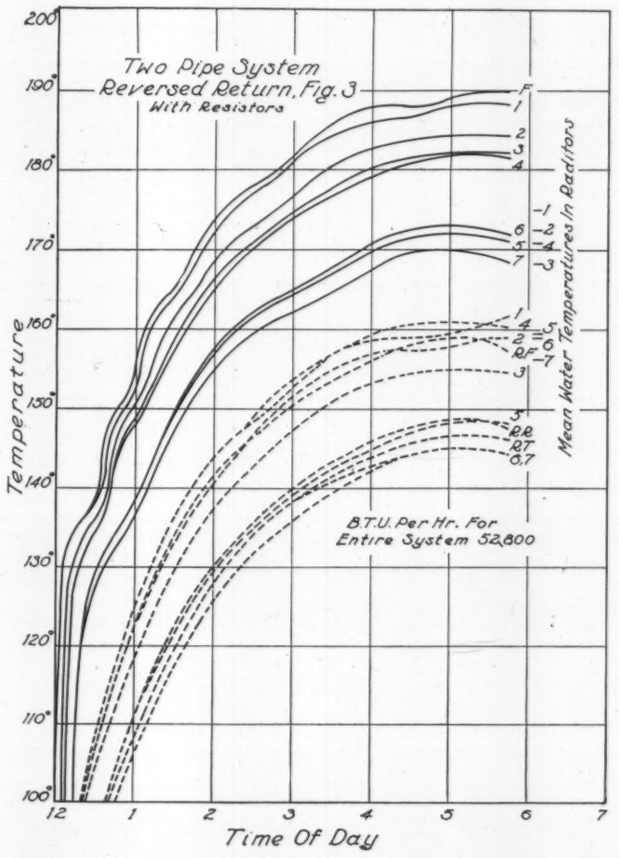


FIG. 16. RECORD OF A TYPICAL RUN FOR THE REVERSED-RETURN SYSTEM WHEN EACH RADIATOR WAS SUPPLIED WITH A RESISTOR OF THE PROPER SIZE

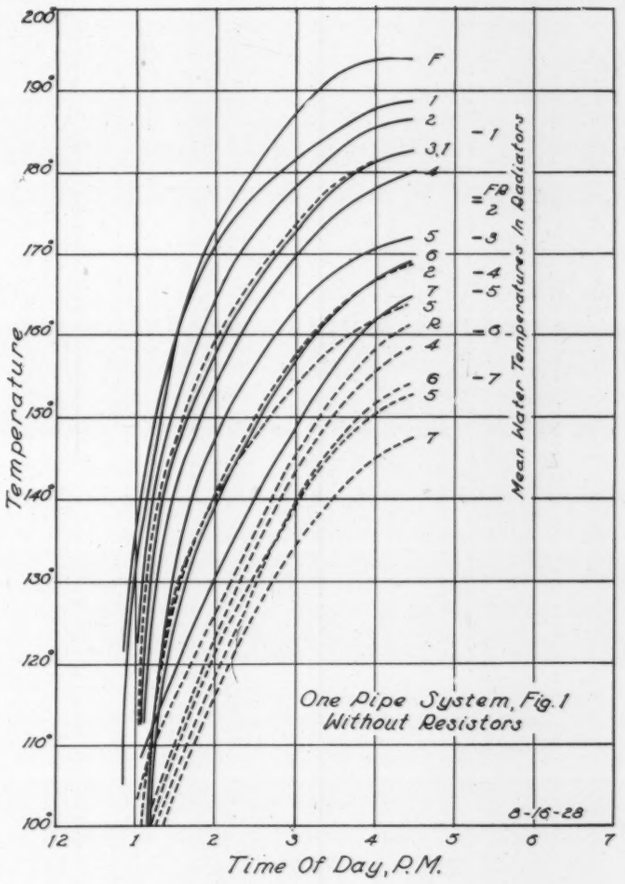


FIG. 17. RECORD OF A TYPICAL RUN FOR THE ONE-PIPE SYSTEM WITHOUT RESISTORS

For both tables, the friction head calculations were based on the "Length of the Horizontal Main," listed in the tables, plus 10 ft. of pipe and 10 elbow equivalents for risers and connections. These additions were assumed to be representative of the ordinary installations.

A comparison of Table 1 with Table 2 shows that the size of the main must be increased as the temperature drop through the system is decreased. For example, for a system delivering 200,000 B.t.u., with a length of horizontal pipe of 150 ft., a 4 in. main is required if the temperature drop is to be 35 deg., and a 5 in. main, if the temperature drop is to be 25 deg.

It will be shown below that, as the size of the main increases, the average size of the radiator decreases, thereby offsetting the increased cost of the main and conserving floor space.

Table 3 shows the capacities of risers for first, second, and third floor radiators. The table is based on the assumptions that the vertical distance of the first floor above the main is about 20 in., that the story heights are about 9 ft., that the individual re-

TABLE 3. MAXIMUM CAPACITIES IN B.T.U. OF RISERS FOR ONE-PIPE SYSTEMS*

SIZE INCHES	FIRST FLOOR	SECOND FLOOR	THIRD FLOOR
¾	2,500	6,000	7,000
1	5,000	11,000	12,000
1¼	9,000	20,000	24,000
1½	12,000		
2	21,000		

* If valves are installed in the radiator circuits, they should be of the same size as the pipes. If smaller valves are used, they will introduce larger friction heads than were included in the calculations on which the table is based.

sistances in every radiator circuit are approximately equivalent to 14 elbows, and that the temperature drop through each radiator will be 20 deg. or less.

Tables showing the capacities of risers supplying more than one radiator can be prepared but it is considered best not to propose such tables until after corresponding installations shall have been made and tested.

Rules for Determining Sizes of Radiators for One-Pipe Systems

The correct method of finding the sizes of radiators for one-pipe systems is to assume the total temperature drop through the system and, having done that, to calculate the successive partial drops in temperature which occur in the main at the several return risers. Knowing these partial temperature drops find, *first,* the temperature of the water in every flow riser, *second,* the average temperature of the water in the radiator, *third,* the value of *k* for the particular temperature difference—water to air,—and, *fourth,* the corresponding radiator size.

Using this method in designing a system in which there are 16 sets of risers, it will be necessary to make 16 sets of calculations. This method may be unnecessarily refined and it may be sufficiently accurate to use the following approximate method: Divide the system into four sections so that the radiators in each of the four sections deliver approximately the same quantity of heat to the building. Number the four sections consecutively in the order in which the water flows, so that Section 1 receives the hottest and Section 4 the coldest water. Calculate the sizes of the several radiators in the usual way and then multiply the calculated sizes by the factors shown in the following tabulation:

For a total temperature drop of	Section 1	Section 2	Section 3	Section 4
35 deg.	1.00	1.15	1.30	1.45
25 deg.	1.00	1.10	1.20	1.30

To illustrate the use of the tables and rules proposed above, let it be required to design the one-pipe system shown in Fig. 19.

There are 7 radiators delivering, together, 71,000 B.t.u. per hour.

The length of horizontal main is 160 ft.

Let us adopt 25 deg. as the total temperature drop.

To find the size of the main: from Table 2, a 3 in. pipe is slightly too small and a 3½ in. pipe too large. We could construct the main partly of 3 in. and partly of 3½ in. pipe; or, if the main can be installed more than 3 ft. 6 in. above the center of the heater, we could use a 3 in. pipe. It may be best to adopt the 3½ in. pipe in this case.

To find the sizes of the risers: from Table 3, the largest radiator, No. 7, having a heat output of 15,000 B.t.u. will need a 2 in. riser if located on the first floor, and 1¼ in. risers if located on the second or third floors. The smallest radiator, No. 6, having a heat output of 5,000 B.t.u., will need 1 in. risers if located on the first floor; and a ¾ in. riser if located on the second or third floor.

To find the sizes of the radiators: Let us assume that the water leaves the heater at a temperature of 210 deg. when the system is delivering 71,000 B.t.u. and that the radiators are operating with a temperature drop of 20 deg. The average water temperature in Radiator 1 will then be 200 deg., and the temperature difference—water to air—will be 130 deg. For this temperature difference, and for a 38 in. 3 col. radiator, the value of *k* is 1.36, and the heat transmission is 1.36 x 130, or 176.8 B.t.u. per square foot. Consequently, if all radiators receive water at the same temperature as Radiator 1, the radiator sizes would be as follows: No. 1, 28; No. 2, 57; No. 3, 54; No. 4, 71; No. 5, 79; No. 6, 28; and No. 7, 85 sq. ft.

To divide the heating system into four sections, so that each section delivers, approximately, the same quantity of heat; we would probably place Radiators 1 and 2 in Section 1, Radiators 3 and 4 in Section 2,

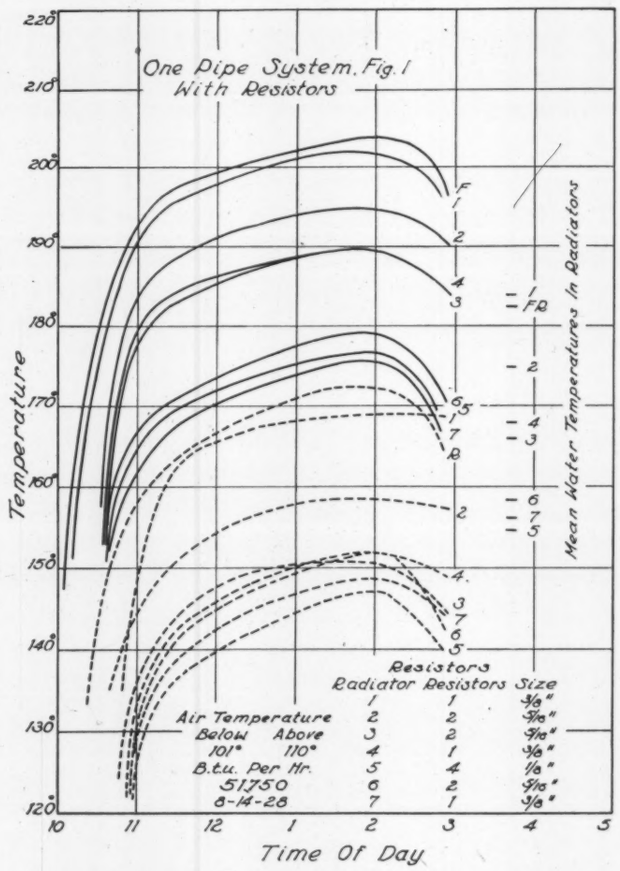


FIG. 18. RECORD OF A TYPICAL RUN FOR THE ONE-PIPE SYSTEM WHEN RADIATORS WERE EQUIPPED WITH RESISTORS

Radiators 5 and 6 in Section 3, and Radiator 7 in Section 4. Multiplying the radiator sizes calculated above by the factors shown under the rules for determining radiator sizes, namely: 1.00, 1.10, 1.20, and 1.30, when the total temperature drop is 25 deg., we find the following sizes: No. 1, 28; No. 2, 57; No. 3, 59; No. 4, 78; No. 5, 95; No. 6, 34; and No. 7, 110 sq. ft. These calculated sizes must be changed to the nearest stock sizes available.

The third experimental installation was the two-pipe direct-return system shown in Fig. 2. Having had the experiences described above with the earlier installations, this system was designed so that the friction head in the risers of each radiator was equal to the pressure head produced by the radiator plus that portion of the pressure head, produced by the heater, which was available for the radiator at the riser connections to the mains. The friction head was provided partly by the pipe line and partly by orifice resistors in the radiator circuit. The resulting operation of the system was very satisfactory as may be seen from Fig. 20, which is a record of one of the experimental runs.

As a final test, the orifice resistors described in Fig. 20 were removed and the system allowed to operate without them. The results secured are shown in Fig. 21, which seems to illustrate very nicely what really happens when a system is said to be *short-circuiting* and which proves conclusively that a system will not function correctly when the friction heads in some of the radiator circuits are too small.

In order to show how accurately a hot-water heating system can be designed, a careful check-calculation was made of the operation of the two-pipe direct-return system shown in Fig. 2, for the operating conditions shown in Fig. 20. The object of the check-calculation is to find whether or not the friction head for every radiator circuit is equal to the pressure head available for that radiator when the calculations are based on the actual conditions existing during the experimental run shown in Fig. 20.

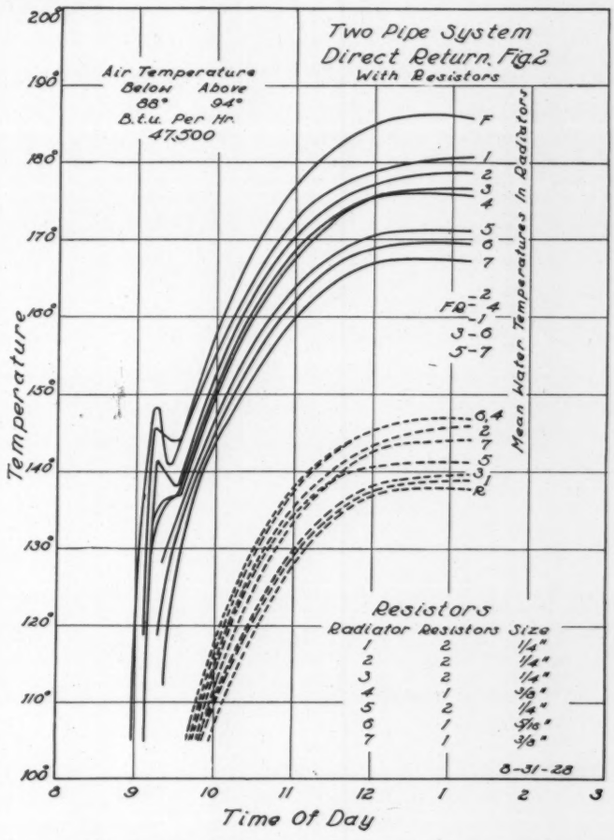


FIG. 20. RECORD OF A TYPICAL RUN FOR THE TWO-PIPE DIRECT-RETURN SYSTEM WHEN THE RADIATORS WERE EQUIPPED WITH PROPER RESISTORS

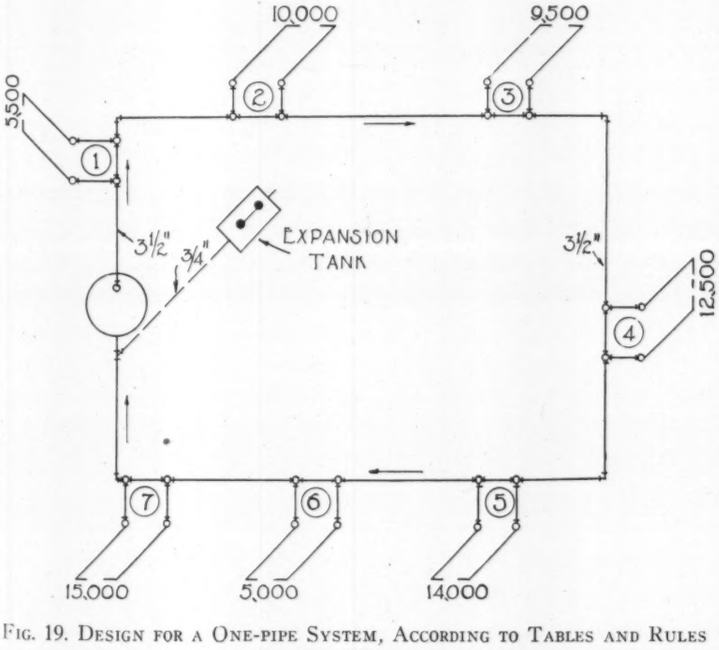


FIG. 19. DESIGN FOR A ONE-PIPE SYSTEM, ACCORDING TO TABLES AND RULES PROPOSED HEREWITH

The calculations are too complicated to be recorded here in detail. The general results for Radiator 1 are as follows:

Heater pressure head (Produced in main flow and return riser)	649 m. i.
Friction head in heater and in mains between heater and connections of risers of Radiator 1	95 m. i.
Remainder of heater pressure head, available to produce flow through Radiator 1	554 m. i.
Radiator pressure head (Produced in radiator flow and return riser)	410 m. i.
Total pressure head available for Radiator 1	964 m. i.
Friction head in radiator and in connected pipe lines	50 m. i.
Friction head in two ¼ in. orifice resistors	1,080 m. i.
Total friction head in radiator circuit	1,130 m. i.

Excess of calculated friction head over calculated pressure head, 1,130—964, or 166 m. i.
Per cent error: 166/964 or +17 per cent.

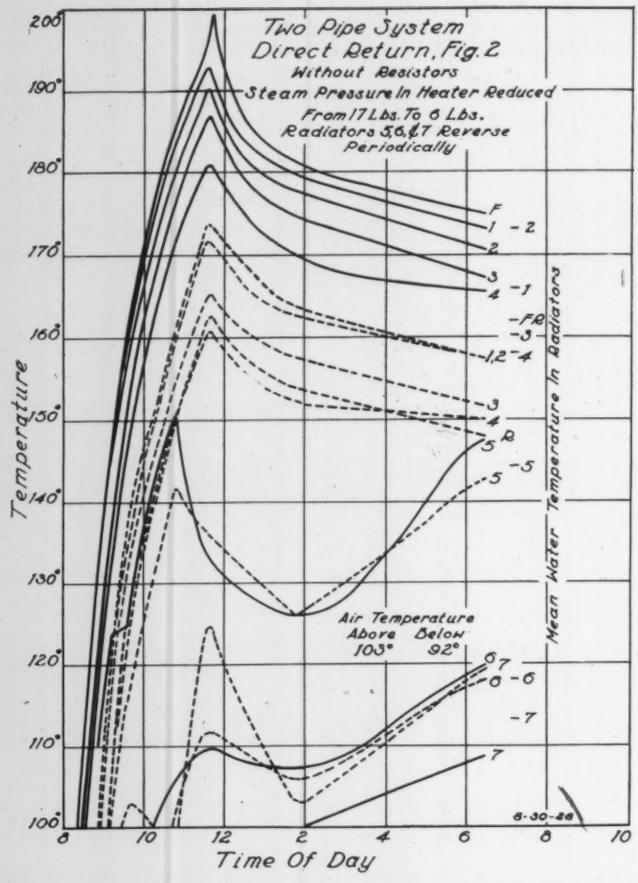


FIG. 21. RECORD OF A TYPICAL RUN FOR THE TWO-PIPE DIRECT-RETURN SYSTEM AFTER THE RESISTORS HAD BEEN REMOVED

Similar calculations were made for the other six radiators and the following general results were found:

Radiator	Calculated Pressure Head	Calculated Friction Head	Per cent Error
1	964	1,130	+17
2	835	920	+10
3	780	844	+ 8
4	590	515	—13
5	1,729	1,037	—40
6	1,322	1,214	— 8
7	379	375	— 1

It is evident from these check calculations that every radiator in the system is functioning as would be predicted from a correct design, except Radiator 5.

The calculated friction head in the circuit of this radiator is about 692/1729, or 40 per cent smaller than the actual friction head. No explanation for this large discrepancy could be found unless it be that the velocity of the water in the flow riser is so low that the water in contact with the pipe cools sufficiently to reverse the direction of its flow along the outer portion of the stream, as sketched in Fig. 22. If such a condition should exist it might account for the high friction head which was found in the actual installation and it would suggest the existence, in the flow risers of hot-water heating systems, of a "critical velocity" below which the system will not function correctly.

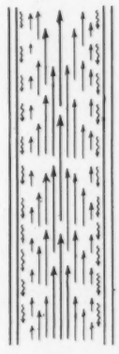


FIG. 22. POSSIBLE DOUBLE FLOW, CAUSED BY COOLING DURING LOW VELOCITIES, IN A FLOW RISER, PRODUCING AN EXCESSIVE FRICTION HEAD

The subject of a *critical velocity* in hot water heating pipes may be very important and well worth careful study as a separate research project, in connection with additional studies, similar to those described in this paper, which will be necessary before tables can be safely proposed that may be used in the design of two-pipe heating systems.

In conclusion, the authors express their appreciation of the valuable assistance given them in this work by G. H. Glover and W. H. Badgett, seniors in Texas Agricultural and Mechanical College, especially in the preparation of diagrams and with the check-calculations.

Instruments for the Measurement of Air Velocity

By J. H. Parkin,[1] M. E., F. R. Ae. S., Ontario, Canada
NON-MEMBER

A DESCRIPTION is given of certain anemometers of the pressure type for measuring the velocity of air under low pressures. The construction, characteristics and limitations of the instruments are discussed and the precautions to be observed in their use are described.

Introduction

The measurement of fluid velocity is of great importance in many branches of engineering. In steam and hydraulic plants, waterworks and sewerage systems, it is necessary to know the rate of flow of water in pipes and conduits, and flowing in open channels its speed must be measured in irrigation work and stream gauging. Steam velocities are now regularly measured in power plant and industrial practice. The velocity of flow of gases, such as air, natural and illuminating gas, has commonly to be determined. In marine and aeronautical transportation the velocity of water or air relatively to the vessel or aircraft determines the speed of travel.

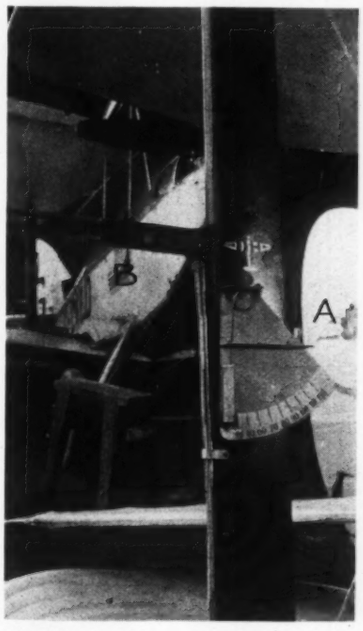


FIG. 1. PRESSURE PLATE ANEMOMETER FOR AIRCRAFT PITOT-STATIC AIRCRAFT HEAD

While the fundamental principles underlying the different methods employed for measuring the velocities of liquids and gases are generally the same, special modifications in apparatus or technique are often adopted for the measurement of any particular fluid. Thus, while certain methods of velocity measurement are peculiar to liquids and others to gases, many are applicable either to liquids or gas, as, for instance, the pitot-tube or venturi meter; while others, but little modified, may be used for either. For example, the current meter employed in river gauging differs in no way fundamentally from the cup anemometer employed for determining wind velocity.

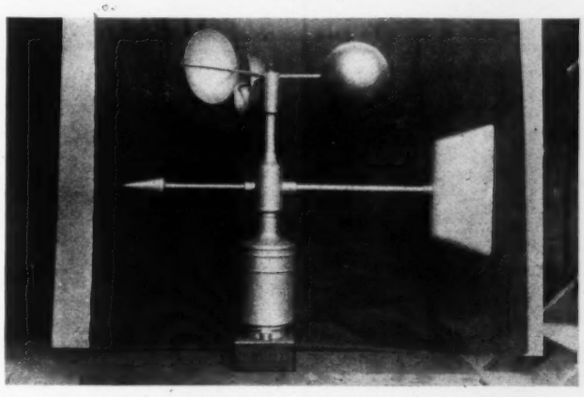


FIG. 2. THREE CUP METEOROLOGICAL ANEMOMETER (CANADA)

The measuring instrument employed will depend, to a large extent, on the particular conditions, such as the nature of the fluid, its velocity and pressure, and whether the flow is in a closed pipe or open channel. Certain devices measure the general average velocity over a considerable area, while others measure the velocity virtually at a point. The velocity required may be that of a fluid through a pipe or channel, or that of some object through relatively stationary fluid, as in vessels and aircraft.

It is proposed to confine this paper to a consideration of certain methods for the measurement of air velocity

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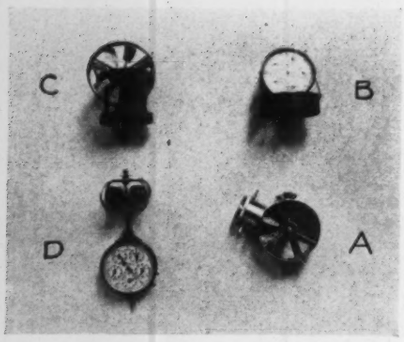


FIG. 3. CUP AND VANE ANEMOMETERS

under atmospheric or low pressure. Certain of the methods described will be applicable only to these conditions, while others, it will be apparent, may be used either directly or with minor modifications for the measurement of flow under pressure in pipes, not only of air and other gases, but also of water and liquids. The methods described will be those for the determination of velocity at a point.

Desirable Features in an Air Speed Indicator

There are certain desirable features to be sought for in selecting an instrument for use under any particular set of conditions. The instrument should be simple and direct in design, with few parts and direct connections, compact and rugged. Convenience in using the instrument is not an unimportant feature, since its absence may reduce the accuracy of the observations through fatigue. Thus, ease of reading, thereby eliminating eye strain, and direct reading, that is, indicating the velocity directly in the desired units, are desirable features.

The accuracy and sensitivity required will vary with the circumstances. The precision of the instrument, however, should be permanent, suffering no deterioration in service. Aside from the inherent accuracy of the instrument, the precision of the observations may be limited by other factors, the most important being unsteadiness or fluctuations in the velocity being measured. The effect of pulsations may be reduced by the introduction of damping in the instrument, but the greater the damping, the more sluggish it becomes, and the greater the time lag which may introduce errors in the indicated velocity.

Instruments may be self indicating or manual. Those of the former type indicate any velocity within their range without manipulation, while the latter require adjustment for each reading. If velocities of varying magnitude are to be read, the self indicating type will generally prove the more convenient; while, if the instrument is being used to enable a velocity to be held constant, there is no difference between the self indicating instrument and the one that has to be adjusted manually.

Another feature to be considered is the size of the instrument and whether it is such as to alter the conditions of flow being studied. Thus, an instrument of considerable bulk should not be employed in a small pipe where the obstruction would materially change the rate of flow.

Whether an instrument is a self standard, such that velocities can be determined directly from the reading and its dimensions, or requires calibration against a standard, is perhaps not important provided that, if of the latter type, comparison with the standard is made at sufficiently frequent intervals. This, however, is seldom done. On the other hand, self standards are often less simple in construction and less convenient to use than calibrated instruments.

Types of Air Speed Indicator

Air speed indicators, or anemometers, may be broadly divided into two classes, pressure type anemometers and electrical anemometers. Anemometers of the pressure type are actuated by the pressure exerted by the air due to its velocity, while the electrical instruments depend for their action upon the dissipation of heat from electrically heated wires in the air stream. The present paper will deal only with instruments of the former type.

There are two principal kinds of pressure anemometers, namely, mechanical or moving part anemometers, such as cup or vane instruments, and pressure tube anemometers of the pitot or venturi tube type. In the former type of instrument the air reaction on a surface, vane or cup, is the active force, while in the latter the dynamic pressure of the air is employed. Most instruments of the mechanical type are practically independent of the density of the fluid, except as it affects the friction, while the indication of instruments of the pressure tube type depends on the density of the fluid.

1. Mechanical Anemometers

A—Pressure Plate Anemometers: The simplest form of anemometer employing the air reaction on a surface is that in which a plate is deflected by the air flow against the resistance of gravity or a spring. Thus, in the pendulum anemometer a rectangular plate is hung on knife edges at its upper edge and loaded near the center. When placed normal to the air flow the plate is deflected until the restoring force due to gravity balances the air reaction on the plate. The angle of swing is indicated on a graduated quadrant, which may be calibrated to read in suitable units. Similar instruments using disks, or in which the plate is moved horizontally against spring resistance, have been used.

The obstruction offered by such instruments to the air flow is a serious disadvantage for many purposes, while the accuracy of the instrument is not great. In addition, the indicator is dependent on the density of the fluid. On the other hand, the instrument gives an instantaneous indication of velocity.

Recently, the principle of the pendulum anemometer has been adopted in an instrument for indicating the approximate speed of aircraft[2] as shown in Fig. 1, *A*. A small plate, about a 2-in. square, is carried on the lower end of a wire arm, initially vertical, which at its upper end is coiled to form a torsion spring. The air pressure deflects the plate against the spring resistance along a quadrant graduated in miles per hour. The instrument is mounted in an unobstructed position on an interplane strut where it is readily visible from the cockpits. It would seem that a similar instrument of small size and with a lighter spring might be useful for measuring roughly low air velocities in heating and ventilation and like work.

B—Cup Anemometers: Cup anemometers consist of a number, usually four, of hemispherical cups mounted on

[2] Employed on the De Haviland Moth light aeroplane.

arms radiating in a horizontal plane from a vertical spindle free to rotate in anti-friction bearings, and furnished with a revolution counter. When placed in the air stream, the cup on one side is presented concave side to the air flow, while the cup on the opposite side is presented convex side to the flow. The coefficient of resistance of the cup in concave presentation being 0.665, while that of the cup in convex presentation is 0.165, the former moves with the air forcing the latter against the air flow, and the cups and spindle are thus rotated windmill fashion.

The speed of rotation, and hence the indication, is approximately proportional to the air speed, instead of the square of the air speed, as in the pressure tube instruments, and hence the cup anemometer is more suitable for measuring low air speeds.

The original so-called Robinson cup anemometer had four cups and was the standard instrument employed to measure wind speeds. Recently, as a result of a most complete study of cup anemometers made by J. Patterson of the Meteorological Service of Canada in the wind tunnel of the University of Toronto, in which a great number of combinations of cup diameters, numbers of cups, arm lengths and cup forms were investigated, it was found that a three cup arrangement has more uniform turning moment and, hence, more constant factor than the four cup. The factor is the relation between the distance moved through by the cups and that travelled by the air in a given time; in other words, it is air speed divided by cup speed. As a result, a new type anemometer having three 5-in. cups on arms 6.3 in. long has been introduced and adopted by the Canadian, American and other meteorological services. The Canadian standard anemometer is shown in Fig. 2.

Cup anemometers range in size from the large outdoor instruments used in meteorological work, such as the Kew pattern having 9-in. cups on 24-in. arms, or that described in the foregoing, to the small instrument shown at *D*, Fig. 3, having four 0.827 in. cups on 0.710 in. arms.

Cup anemometers are ordinarily of the indicating type in which revolutions of the cup spindle are indicated by needles on graduated dials, and to determine the air speed an independent time observation with a stop watch must also be made. Such instruments may have the dials directly on the instrument, the needles being driven through suitable gear trains, as in the small instrument at *D*, Fig. 3, or a contactor only may be incorporated in the anemometer with a remote electrical recording or indicating device, as in the meteorological instrument of Fig. 2. There are also tachometer cup anemometers which indicate the air speed directly.

Friction, lubrication and inertia have important effects on anemometers of this type. While every effort is made to reduce friction to a minimum by using anti-friction bearings in the large instruments and jewel pivots in the small instruments, friction still introduces inaccuracies, particularly at low speeds. In addition, the gear trains connecting the spindle and indicating needles impose a considerable friction drag on the spindle. Curves showing percentage errors in the readings for two cup anemometers are shown in Fig. 4, and it will be seen that the accuracy of the indication is much reduced at low speeds.

Inertia of the rotating element results in too high an indication of velocity in a fluctuating air current. The instrument is sluggish. Light construction minimizes this trouble.

An important characteristic of cup anemometers is that the air speed from *any* direction in the horizontal plane is indicated.

C—Vane or Screw Anemometers: This type of instrument is similar to the cup anemometer except that instead of cups, light blades or vanes set at an angle to the plane of the arms, windmill fashion, are used. When the axis of rotation is parallel to the air flow the air reaction on the vanes has a circumferential component which rotates the spindle. Revolutions of the latter are indicated either directly on suitable dials, or an electrical contact is made after a certain number of spindle revolutions, which enables distant electrical observation to be employed.

The vane anemometer can be made of somewhat lighter construction than the cup type and, hence, is more sensitive. Mica or aluminum vanes are used and jewel bearings. This type of instrument is extensively used in ventilation and mine work. It is a delicate instrument

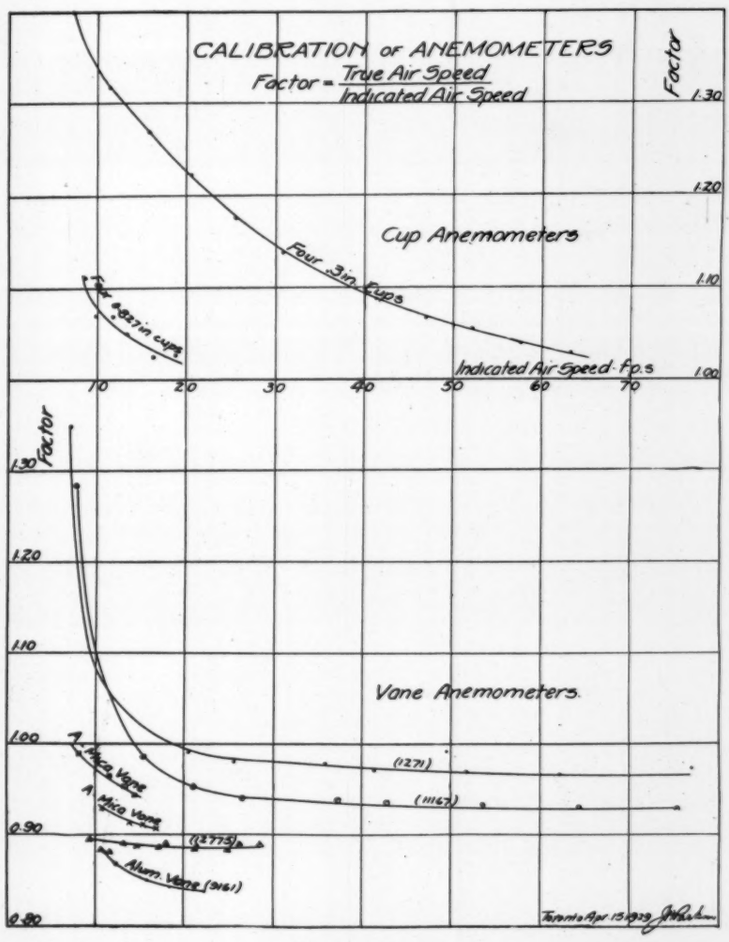


FIG. 4. CHART

requiring careful handling and it should not be used for velocities over 50 ft. per second or 3,000 ft. per minute.

The vane instrument, unlike that with cups, due to the presence of the protecting cylindrical case, requires to be more or less accurately aligned with the direction of air flow. As with the cup anemometer, a time observation is necessary to determine the velocity and friction at the spindle, and gear trains reduce the accuracy. This latter effect is shown for different vane anemometers by the curves of Fig. 4. Inertia effects are negligible with the light construction employed.

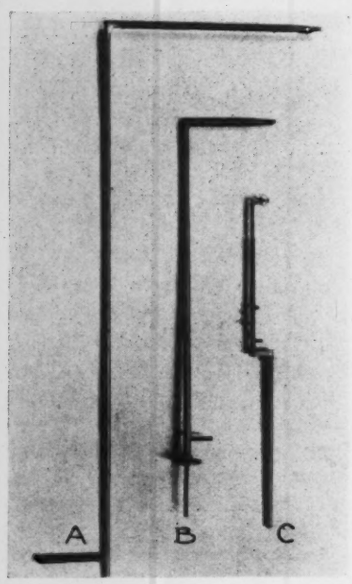


FIG. 5. PRESSURE TUBE ANEMOMETERS

In general, one of the three positions is used for the indicating mechanism, two of which are shown at *A*, *B* and *C*, Fig. 3. That in which the dial case is directly behind the windmill as at *B* and *C* probably has the greatest interference effects, while that with the small case on the outside of the cylindrical casing ring, as at *A* would be expected to have least. The third position for the dials is in the center of the wheel concentric with the wheel and case and normal to the air flow. This last arrangement is more compact, attractive in appearance, and the interference probably less and more consistent than in the first position. However, the observer is more likely, with the latter instrument, to stand in such a position that he interferes with the air flow through the instrument.

2. Pressure Tube Anemometers

Anemometers of this class may be divided into pitot type and venturi type instruments.

A—Pitot Tube: The pitot tube is simply an open ended tube facing the current. The air, or other fluid, flowing into the open end is brought to rest and thereby exerts a pressure on the air in the tube equal to the dynamic pressure. The latter is expressed by the relation $\rho\frac{v^2}{2}$, ρ being the mass density of the air or fluid, *i.e.*, $\frac{w}{g}$ where w is the weight in pounds per cubic foot and v in feet per second. The pitot tube is commonly employed in conjunction with a second tube in which the pressure is equal to the static pressure in the air stream, so that the pressure difference between the tubes is the dynamic or velocity pressure. The combination is known as a pitot-static tube, or, less correctly, simply as a pitot tube.

It has been found that the form of the open end of the pitot tube is not important since, with forms as widely different as a hole in a disk and a finely tapered tube end, the pressure in the tube is found to be the correct dynamic pressure. On the other hand, great care must be taken in forming the end of the static tube if the true static pressure is to be obtained in the tube. The most satisfactory arrangement consists of one or more holes (static openings) of diameter not greater than 0.04 in. drilled in the walls of a tube whose axis is parallel to the air stream. The end of the tube is closed and faired or pointed so that the air flows in smooth parallel streams past the static openings. It is important that the latter should be of small diameter, drilled normal to the surface and with all burrs removed.

In some instruments the pitot and static tubes are quite separate, as in the aircraft air speed head, shown at *B*, Fig 1. Commonly, however, the pitot and static tubes are combined in one instrument as shown at *A* and *B*, Fig. 5. These instruments each consist of two concentric tubes of about 3/16 in. and 5/16 in. O. D. The smaller, inner tube is the pitot tube extending from the pitot, or impact opening, to the corresponding pressure connection. Surrounding this tube is the larger static tube in which, near the nose, the static openings are drilled. The static openings should be 2 or 3 in. (not less than six diameters) back of the tapered nose and about 10 in. ahead of the heel or shank. The nose should be finely tapered, not to improve the dynamic opening, but so that the air will flow smoothly past the static openings at all speeds, thus permitting the true static pressure to be obtained.

The theory of the pitot tube is well known. It is commonly developed on a basis of Bernouilli's theorem, considering the air incompressible, but more correctly from the principles of thermodynamics, taking into account the compressibility of the air. In the latter case for adiabatic compression, the pressure on the impact opening is

$$p = p_o \left(1 + \frac{(\gamma - 1)\ \rho_o v^2}{2\gamma\ p_o}\right)^{\frac{\gamma}{\gamma - 1}}$$

so that a pitot-static tube transmits to a differential gauge the difference between this pressure and the normal static pressure, or

$$p - p_o = \frac{\rho_o v^2}{2} + \frac{1}{\gamma - 1}\frac{\rho_o v^2}{2} + + +$$

In this expression all terms after the first are negligible to a precision of 1 per cent for speeds below 225 ft. per second and the equation reduces to that developed on a basis of Bernouilli's theorem.

The pitot-static tube, constructed as described in the foregoing, therefore, requires no calibration, the equation

$$p = \frac{\rho v^2}{2}$$

applying with an

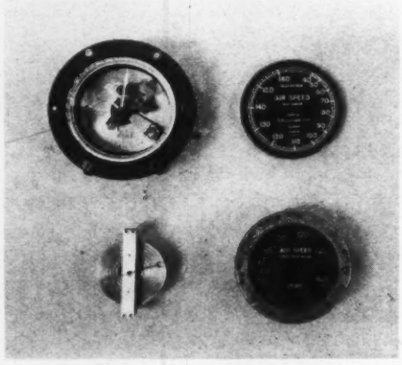


FIG. 6. MECHANICAL GAUGES

accuracy of 1/10 per cent of the velocity up to 50 ft. per second (3,000 ft. per minute) and 1 per cent up to 225 ft. per second (13,500 ft. per minute). At a speed of 40 ft. per second (2,400 ft. per minute) the pressure difference between the tubes is only 0.365 in. of water, and this small pressure together with the fact that it varies as the square of the speed, and hence is very small indeed at low speeds, are the principal disadvantages of the instrument.

Owing to the small magnitude of the pressure difference for ordinary air velocities, various modifications have been introduced to increase the reading. In one case an aspirator tube replaces the static tube. The aspirator tube may simply be a pitot-tube with open end downstream, as in the so-called double pitot, or the open end of a tube pointing upstream is covered by a small conical cap with open base downstream. The pressure inside the cone is then less than the normal static pressure. This construction is employed in the Clift aircraft head and in the yawmeter shown at *C*, Fig. 5.

No theory has been developed for this type of tube, as it involves a consideration of the external flow about the tube and the negative pressure at the rear. The pressure difference between the two tubes may be 40 per cent greater than that between the tubes of the ordinary pitot-static tube, and if the formula of the latter is used, a coefficient must be used, ranging in value from 1.35 to 1.40.

The pitot-static tube is perhaps one of the most commonly used instruments for the measurement of the velocity of fluids which are clean and not too viscous. It is simple, inexpensive, compact, convenient, of high accuracy and, if properly constructed, requires no calibration. Owing to the small magnitude of the velocity head, the instrument is not satisfactory for measuring velocities below 20 ft. per second (1,200 ft. per minute) for which the velocity head is less than 1/10 in. of water.

There are certain precautions to be observed in the use of the pitot-static tube if accurate results are to be obtained. It is important that the tube be set parallel to the air flow. A misalignment of 4 deg. will cause an error of 1 per cent and 17 deg. misalignment about a 5 per cent error in the reading. The air stream immediately behind the instrument must be free from obstruction. The effect of an obstruction here is to cause the lines of flow to be deflected, and if this deflection occurs at, or upstream, from the static openings, the true static pressure will not be obtained. For this reason the static openings should be well forward, some 8-10 in., of the shank of the instrument, and if the tube is carried on a rod or other support, the latter should be kept well back of the instrument. A hemispherical clamp, 1 in. in diameter, 3 3/16 in. behind the static openings of the tube, shown at *B*, Fig. 5, was sufficient to cause a 1 per cent error in the velocity indicated. For the same reason the tube should not be used too close to a wall or other object, since confining the air flow between the wall and tube will result in an error in the static pressure obtained.

B—Pitot-Venturi Tube: The static tube in the pitot-static instrument is, in some cases, replaced by a venturi tube in order to increase the magnitude of the pressure difference obtained. The double conical form of the venturi tube is familiar to all engineers, and it is well known

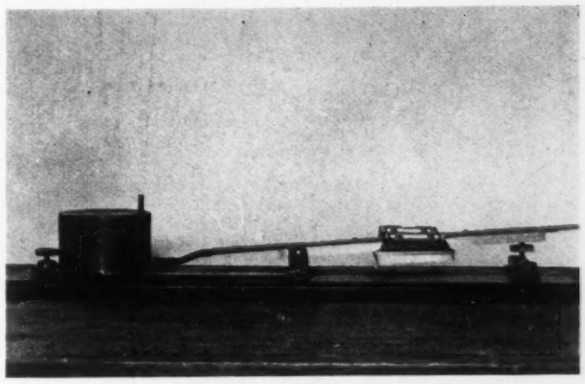


FIG. 7. SLANTING (KRELL) MANOMETER

that a fluid flowing through the meter experiences as a result of the reduction in cross-sectional area in the tapering cone, an increase in velocity, accompanied by a corresponding decrease in pressure. Thus, the pressure at the throat is less than the normal static pressure, and hence the pressure difference between the dynamic pressure of the pitot tube and the reduced pressure at the throat of the venturi tube will be much greater than for the usual pitot-static combination.

The venturi tube may be employed alone, using the pressure difference between the throat and the normal static pressure, but generally, for the foregoing reason, it is used with the pitot tube.

While the theory of the venturi tube inserted in a pipe line is well known, no theory has been developed for the venturi tube in free air when the flow around the outside must also be considered. Considerable research has been done on venturi tubes used in this way, however, and the following points have been determined:

1. The entry cone should be of about 20 deg. angle and from ¾-1 in. long.
2. An exit cone angle of 4 deg. 50 min. and a length of 6 in. are satisfactory.
3. Flaring the base of the exit cone increases considerably the suction.
4. The throat between entry and exit cones should be short, not exceeding 0.03 in.
5. The efficiency of the tube drops with increase in size, a throat diameter of from ⅜ to ½ in. being most satisfactory.
6. There is no advantage in the use of cones with variable angle, *i.e.*, curved surfaces.

The suction obtained can be much increased by using a double venturi tube. A small venturi is arranged in the entry cone of the larger tube, with the end of its exit cone at the throat of the larger tube. The reduced pressure set up by the larger tube serves to increase the flow through the smaller, thereby developing in the throat of the latter a much greater suction. Suctions eight times that of the single tube have been obtained in this way.

Pitot-venturi tubes, both single and double, are used to a considerable extent for indicating the speed of aircraft. The American and French Air Services employ this type of instrument. It would seem to have possibilities as an instrument for use in heating and ventilation work because of the large pressure difference, although its form renders it less convenient to use than the pitot-static tube.

The same precautions must be observed in using this

instrument as for the pitot-static tube. The venturi must be kept at least 25 diameters ahead of any obstruction, even if of fairly stream-lined form, such as an aircraft strut, to prevent blanketing of the tube and loss of suction.

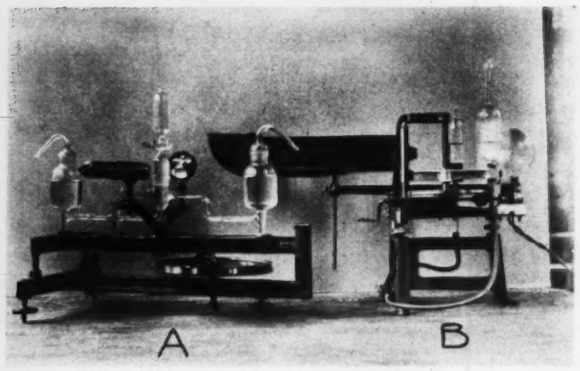


FIG. 8. CHATTOCK MICROMANOMETERS

3. Manometers

Anemometers of the pressure tube type require some form of pressure gauge to measure the pressure difference between the tubes, and because of the small magnitude of this pressure difference, such gauges must possess great sensitivity. A sensitivity of 0.0005 in. of water is desirable, although 0.001 in. is often sufficient. The range required will generally not exceed 3 in. of water, or at the outside 6 in., since the air velocity corresponding to a dynamic pressure of 3 in. of water is 115 ft. per second (6,900 ft. per minute).

The gauges should be free from indeterminate errors due to capillarity, viscosity, hysteresis, friction and inertia. Adjustable damping is desirable to enable the velocity in unsteady flow to be measured. Simplicity and convenience are of much importance. The use of colored liquids, reading of one meniscus only, zero adjustment and scales reading directly in the desired units, all facilitate the taking of the readings and improve their accuracy through eliminating fatigue and needless computations. It is also desirable, as previously noted, that the gauge should be a self standard, if this can be effected without too great sacrifice in convenience or other features.

The gauges employed are usually either mechanical or gravity.

A—Mechanical Gauges: In the mechanical type the movement of a diaphragm, or other similar device, under the action of the pressure difference, is mechanically magnified and communicated to a needle moving on a dial. While non-metallic diaphragms of such material as rubber or parchment have been used, a thin corrugated metal diaphragm or bellows is now most commonly employed, the arrangement being very similar to that of the ordinary aneroid barometer. Gauges of this type, in conjunction with pitot-static or pitot-venturi tubes, are standard equipment on aircraft for indicating air speeds. Two such gauges are shown in Fig. 6, one having a corrugated metallic diaphragm, the other an oiled silk diaphragm.

Mechanical gauges are less simple in principle and more complicated in construction than those of the gravity type. They are subject to errors due to friction in the pivots and hysteresis in the diaphragm. Obviously, such gauges require calibration.

B—Gravity Gauges: The gravity type gauges employed for velocity measurement purposes are basically simply *U* tube manometers, and hence are usually termed manometers or micromanometers. Various modifications are introduced in the simple *U* tube to magnify the reading and so render the gauge more sensitive. These gauges are made either self indicating or manual in operation.

(1) SELF INDICATING MANOMETERS.

In manometers of the self indicating type two methods of magnification are employed.

a—Two Liquid Differential Gauge: In the two liquid differential gauge, two non-miscible liquids of nearly the same specific gravity are employed in such a way that the difference of their specific gravities is the operative factor. Additional magnification is obtained by enlarging the upper portions of each leg of the *U* tube into cisterns of about 100 times the cross sectional area.

Alcohol, colored with analine dye and kerosene, are the two liquids generally used, although water or methylated spirits may be used with the kerosene. The specific gravity of the alcohol may be adjusted by the addition of water to be as nearly that of the kerosene as desired. If the specific gravities are too nearly equal (less than 0.05 difference) the gauge is difficult to manipulate, as the meniscuses become irregular. Methyl alcohol and gasoline and amyl ether and water have also been used. Care must be taken that there are no constituents in the one soluble in the other, and this may be guarded against by keeping the two in the same container before using.

The formula for the gauge in which the lighter liquid is in one leg only of the *U* tube is

$$P_1 - P_2 = R\,(s_2 - s_1) + \frac{A_t}{A_c} R\,(s_2 - s_1)$$

and if in both legs of the *U* tube the expression is

$$P_1 - P_2 = R\,(s_2 - s_1) + \frac{A_t}{A_c} R\,s_1)$$

where R is the movement of the surface of separation.
A_t and A_c areas of tube and cistern, respectively.
s_2 and s_1 specific gravities of heavier and lighter liquids, respectively.

With alcohol and oil of specific gravities 0.834 and 0.79, respectively, a magnification of 17-18 is secured with oil in one leg and one meniscus only has to be read, while with oil in both legs the magnification becomes about 23, but two meniscuses have to be observed.

The tubes should be of ⅛ to ¼ in. bore and length 30 times the desired range in water. With large bores the meniscus becomes indeterminate, and with small bores it may break. The longer the tubes the greater the inertia and consequent lag. With ⅛ in. by 30 in. tubes the lag may be 1 min.

In tests made at the University of Toronto this gauge

was found unsatisfactory. It suffers from errors due to capillarity, viscosity, inertia, hysteresis and imperfections in the tubing. Its precision is low. The accurate determination of the specific gravities of the liquids is an additional disadvantage.

b—Slanting Manometer: In the slanting or Krell manometer, magnification is obtained by inclining one leg of the *U* tube at a small angle to the horizontal, so that for a given vertical displacement of the meniscus, the movement along the tube is much increased. Angles of 3 deg. and 6 deg. to the horizontal are ordinarily used, giving magnifications of 20 and 10, respectively.

The gauge is rendered more convenient by replacing the vertical leg of the *U* tube by a reservoir or cistern having several hundred times the cross sectional area of the slanting tube. This makes it necessary to observe only one meniscus, that in the slanting tube, since that in the reservoir remains substantially constant.

The slanting tube should be uniform in bore, about ¼ in. diameter, and straight.

Alcohol (colored) has been found best for this gauge. The precision when employed with a pitot-static and the velocity calculated from the dimensions is about 1½ per cent, but as the gauge responds to velocity changes of ¼ per cent, if calibrated against a standard, it may have the precision of the standard.

A gauge used with success at Toronto is shown in Fig. 7. The glass tube is clamped with transparent celluloid bands into a *V* groove machined in a flat steel bed. The latter is pivoted at the lower end and provided with an elevating screw on a trunnion at the other end. Two steel wedges, machined to angles of 3 and 6 deg., respectively, attached to the bed, carry spirit levels. By adjusting the elevating screw until one or other of the spirit levels is level, the inclined tube is brought to a slant of 3 or 6 deg. to the horizontal, irrespective of the position of the base of the gauge.

The *V* groove keeps the tube straight, and by marking the glass tube it can always be returned, after cleaning, to the position it occupied when calibrated. A strip of white paper behind the glass tube improves the visibility greatly, and by bevelling one edge of the graduated scale to a knife edge and fitting it to project halfway over the glass tube, errors in observation, due to parallax, are much reduced.

The reservoir is of spun copper 5 in. in diameter by 3 in. deep, and should be insulated to eliminate temperature effects. The reservoir is provided with an elevating screw so that the meniscus may be adjusted to zero on the scale.

This particular gauge has been found most satisfactory for many purposes. It is simple, inexpensive, precise, consistent, very quick to respond and convenient to read. Errors due to capillarity and inertia are small.

(2) Manual Adjustment Manometers.

In manometers of the manual type, instead of permitting the liquid to flow from one leg of the *U* tube to the other to balance the applied pressure difference, one leg of the *U* tube is raised bodily, without allowing the liquid to flow in the tube, to establish the difference in level of the liquid necessary to balance the pressure difference. The distance through which the leg is raised from the zero position to maintain equilibrium is then equal to the applied pressure difference. Troubles due to capillarity are thus avoided, since theoretically there is no movement of liquid in the tube. To insure that there is no such movement there is incorporated in these manometers some form of sensitive indicating device designed to show the slightest movement of the liquid. The more sensitive this device the greater the sensitivity of the manometer.

a—Chattock Micromanometer: One of the best known gauges of this type is the Chattock tilting gauge shown at *A*, Fig. 8, which is largely used with the pitot-static tube in aerodynamic laboratories. The gauge consists of a *U* tube in which each leg is enlarged to form a bulb of about 2 in. diameter. The flow indicating device is located in a vertical tube about 1 in. in diameter, midway between the bulbs. The tube from one leg or bulb is carried up centrally in the 1 in. tube, terminating in an open end, the edges of which are ground off to a knife edge. The tube from the other leg enters the side of the 1-in. tube. The upper part of the 1-in. tube is filled, from a reservoir above it, with oil to a level below the top of the central tube. The remainder of the gauge is filled with water. The water rises in the central tube and forms a meniscus or bubble in the oil at the top. Evidently, the slightest flow of water from one leg of the *U* tube to the other will distend or contract this bubble. A microscope fitted with a hair line is focused on the bubble with the hair line tangent to the latter, and enables minute movements to be detected.

The whole of the glassware described in the foregoing is carried on a tilting frame controlled by a micrometer screw and dial.

The applied pressure difference tends

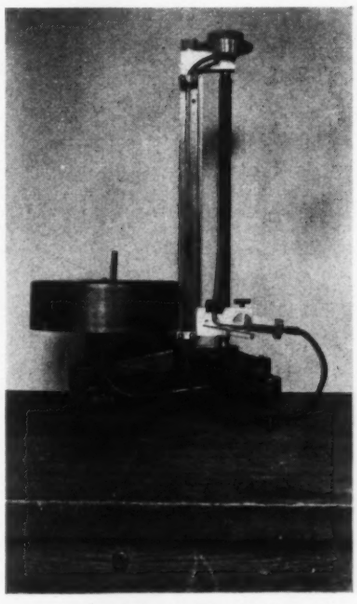


Fig. 9. Direct Lift Gauge

to displace the water from one leg of the *U* tube to the other, this distends the bubble and the U tube is tilted by means of the micrometer screw until the head, due to the difference in level of the two bulbs, balances the applied pressure, as is shown by the bubble remaining tangent to the hair line of the microscope. From the dimensions of the gauge and pitch of the screw, the change in elevation, and hence the pressure, may be calculated.

The center to center distance of pivots and bulbs should be known to within 0.001 in. and the pitch of the screw to within 0.0001 in.

In the original Chattock gauge castor oil was employed, and to prevent it clouding through contact with the water, brine was used instead of water. This proved awkward, necessitating the determination of the specific gravity of the brine. In the gauges now used at Toronto, distilled water and a medicinal paraffin oil have been used with success.

The Chattock gauge is very sensitive. A pressure change of 0.00025 in. of water can be readily detected. It is an absolute standard. While temperature changes affect the accuracy, the effect for ordinary temperature changes is small. The chief disadvantages of the gauge are the fragile nature of the glassware, the extreme care necessary in use to avoid rupturing the bubble, and the eyestrain involved in long continued observation through the microscope.

b—Modified Chattock Gauges: The first and last of the difficulties mentioned in the previous paragraph have been eliminated in a modified design developed in England. Gauges of the modified design, as made and used at Toronto, are shown at *B*, Fig. 8. Instead of the tilting arrangement, one bulb is raised vertically on a micrometer screw. The bubble indicator and the second bulb are combined to form the other leg of the *U* tube. The two legs are connected by a rubber tube in which a glass stop cock is inserted. The glassware is thus simple.

Instead of the microscope, the enlarged images of the bubble and hair line are projected on a ground glass screen rendering observation easy. The bubble is illuminated by means of a concentrated filament stereopticon lamp. Spirit levels are fitted to enable the gauge to be properly levelled.

It is evident that the accuracy of this gauge depends solely on the accuracy of the micrometer screw. The gauge is as accurate as the screw. The gauges used at Toronto are sensitive to 0.0001 in. of water. While this type of gauge, particularly in the latter form, is an excellent laboratory instrument, it is probably too delicate and sensitive for use in ordinary engineering practice.

c—Direct Lift Gauge: A more satisfactory form of manometer for general use, possessing almost equal accuracy, and of simpler and more robust construction, is the so-called direct lift gauge, shown in Fig. 9.

In this gauge a large spun brass reservoir forms one leg of the *U* tube, and is connected through rubber tubing to a short length of glass tubing mounted on a metal bracket, which can be rotated about a horizontal pivot, so that the tube may be set at any inclination to the horizontal (as in the slanting Krell gauge). The pivot is carried by a block which can be raised or lowered by means of a micrometer screw and dial. The gauge is filled with colored alcohol whose specific gravity must be accurately determined.

The meniscus in the slanting tube, with the gauge at zero, is adjusted by raising or lowering the brass reservoir (using screw below) until it is tangent to a hair line engraved on glass mounted in front of the tube. Parallax is avoided by using a mirror behind the tube.

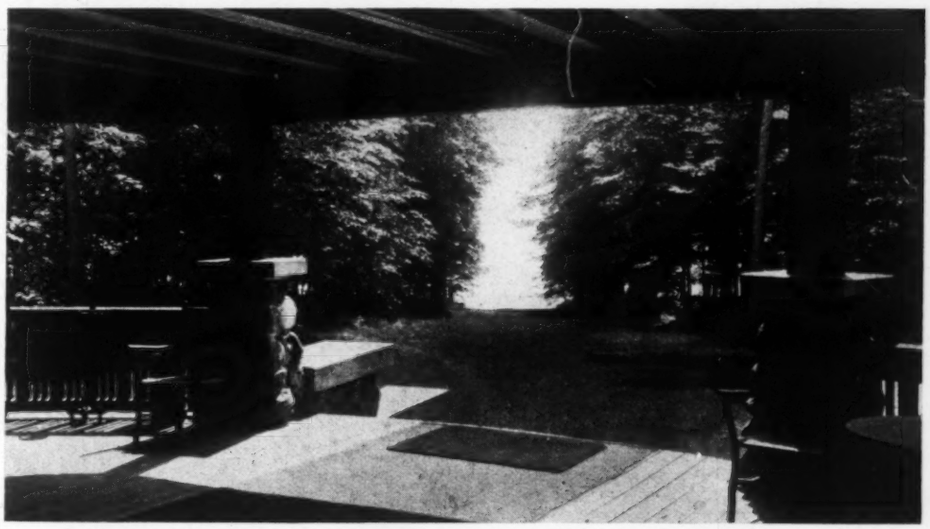
The alcohol, under the action of the applied pressure difference, tends to rise in the slanting tube, and this tendency is counteracted by raising the tube bodily by means of the micrometer screw, keeping the meniscus tangent to the hairline. The amount the tube is elevated is then the pressure difference in inches of alcohol. The sensitivity of the gauge may be varied by adjusting the slope of the inclined tube.

This manometer is evidently a self standard whose precision depends only on the accuracy of the micrometer screw. The use of the large reservoir renders it necessary to observe one meniscus only. The range of the gauge can be made quite large, that illustrated having a range of 10 in. of alcohol.

The direct lift gauge should prove very useful in heating and ventilation work for the accurate measurement of fairly constant pressures and velocities.

d—Wahlen (Illinois) Gauge: The Wahlen gauge, developed at the University of Illinois, is similar in form to the direct lift gauge, but employs a different indicating device. The tube connecting the two bulb arms of the *U* tube is bent upward to form an inverted *U* tube of which one arm is enlarged and the other constricted to a very fine bore (3 m.m.). The upper part of the inverted *U* is filled with a mixture of kerosene and ligroin, the surfaces of separation between the mixture and the alcohol, with which the rest of the gauge is filled, being located in the enlarged and constricted sections of the inverted *U*. The slightest movement of the liquids in the instrument under the action of a pressure difference is then greatly magnified in the movement of the meniscus in the fine bore tube from a reference line engraved on the latter. This movement is counteracted by raising one bulb of the main *U* tube by means of a micrometer. A movement of the micrometer screw of 0.001 in. moves the meniscus 1/16 in. in the fine bore tube, if the difference in specific gravity of the kerosene-ligroin mixture and alcohol is adjusted to be 0.0085. The necessity of maintaining the difference in specific gravity of the two liquids within rather narrow limits is emphasized in the description of the gauge and would appear to be a disadvantage. It is stated that the gauge is accurate and sensitive to a pressure difference of less than 0.0001 in. of water.

PRESIDENT'S PAGE



VISTA FROM THE ROTUNDA, BIGWIN INN, LAKE-OF-BAYS, ONTARIO, CANADA

THE date for the Semi-Annual Meeting at Bigwin Inn is almost here. A program of technical sessions and a schedule of outdoor events are offered for the pleasure of those who come to Canada.

Three important codes will be discussed at the three morning sessions, together with a limited number of technical papers. All papers have been published in advance, and plenty of opportunity will be given for discussion. Some of the most important problems confronting the heating and ventilating profession are to be considered at this meeting.

The report of the Boiler Rating Committee is awaited with interest. Splendid progress has been made by Mr. Harding's Committee. A need has been felt for a standard method of testing unit heaters, and through the efforts of the Society's Committee, and the manufacturers' co-operating committee, a code will be submitted.

The work of the Society's Committee on Garage Heating and Ventilating has been recognized and it is a pleasure to report that the National Fire Protection Association, at its meeting in May, approved the work of the Society's representative and adopted the suggestions as a part of its Garage Code. A similar code will be submitted at the Bigwin meeting.

Each member has received a recommendation from the Council, approved May 13 in Cleveland, relating to the establishment of a Society Endowment Fund. This matter will be discussed and voted on at the June 26 meeting.

There are many things to do at Bigwin. The meeting this year offers some unusual attractions. To get the most from Society membership—attendance at meetings, service on committees, and preparation of papers and discussions are important functions.

Are you making plans to attend this important Society event? Will you participate in the splendid program arranged by our Canadian Hosts? Will you be with me at Bigwin June 26-28?

Sincerely and cordially yours,

Thomas Lewis

President.

May 15, 1929.

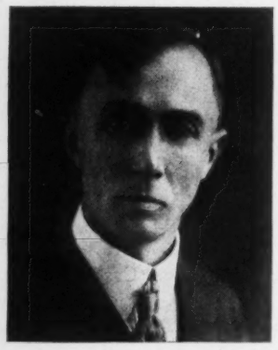
PROF. A. P. KRATZ

M. E. O'CONNELL

F. C. HOUGHTEN

CARL GUTBERLET

J. F. QUEREAU



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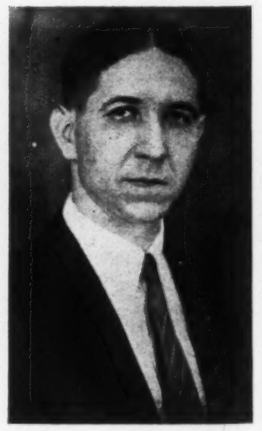
P. D. CLOSE

JAMES GOVAN .



E. G. SMITH

Make Bigwin Meeting a Big One

June 26 to 28, 1929

THE program for the Semi-Annual Meeting of the Society at Bigwin Inn, Lake-of-Bays, Ontario, June 26 to 28, has been completed by the Committee of the Ontario Chapter and some unusual entertainment events are in store for those who Come to Canada for this three day meeting in the Highlands-of-Ontario.

Chairman H. H. Angus and his Program Committee have provided nine technical papers on subjects of current interest. Two of the authors, Prof. J. H. Parkin and James Govan, are Canadians, and have written papers on timely topics. Research studies from three Universities and from the Society's Laboratory in Pittsburgh, cover warm air heating, dustiness of air, steam and hot water heating pipe sizes and heat transmission.

Two other extremely important papers cover the air conditioning of an office building and proposed methods of selecting insulations.

Several of the authors are well known to Society members and others make their first appearance in presenting papers. The authors are pictured and all have promised to appear in person to give their papers and answer questions in the discussion.

Under the able leadership of M. Barry Watson, the Committee on Arrangements of the Ontario Chapter, has prepared a program for the members and ladies who attend, that will keep them entertained as long as they remain in Canada.

Early on Tuesday morning, June 25, Melvern F. Thomas and his Reception Committee will greet the members arriving in Toronto and will escort them to the registration and information booth provided by the local chapter, and entertain them until the special Bigwin Inn train leaves the Union Station at noon.

After arrival at Bigwin Inn dinner will be served between the hours of 6:30 and 8:00 p.m. A special program in the Rotunda has been arranged by Arthur S. Leitch, chairman of the Entertainment Committee. An informal reception and dance will be held in the Pavilion and motion pictures will be shown.

On Wednesday while the technical session is in progress the ladies will take a special hiking trip on Bigwin Island, beginning at 10:30 a.m. After luncheon a special boat trip around Bigwin Island has been arranged. At the same time the men will play in the Research Cup Golf Tournament.

On Wednesday evening an amateur theatrical entertainment by a specially selected cast of Ontario Chapter members will be given in the Pavilion and this will be followed by a masquerade ball in the Ballroom of the Inn.

On Thursday morning arrangements have been completed for a golf tournament for the ladies and in the afternoon they will be entertained at a bridge party and tea. At 7:00 p.m. the Semi-Annual Banquet and Dance will be held in the main dining room of Bigwin Inn.

Friday afternoon has been set aside for various sports and will be featured by golf matches, a tennis tournament, lawn bowling contests and a special International Motor Boat Race will be participated in by representatives of each Chapter.

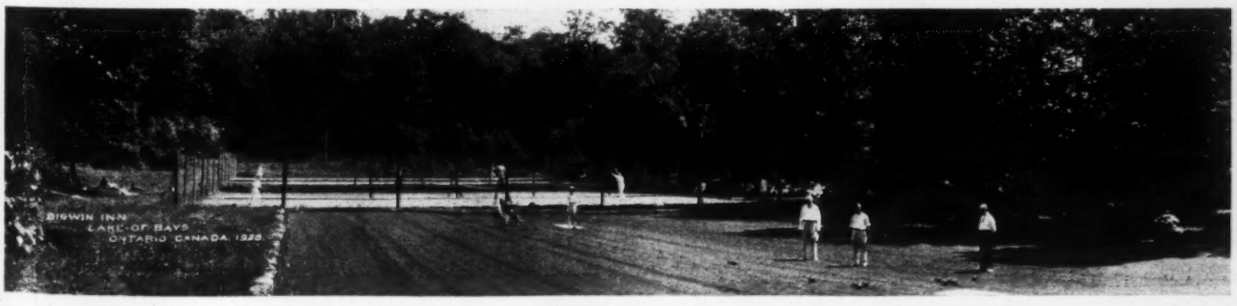
The concluding event will be a Log Rolling Contest by local talent.

This attractive program has been provided in a setting of primeval beauty in the northern lake district of Ontario where not more than 50 years ago Chief Bigwin and his Indian band roamed the woodlands on hunting expeditions.

Today this same land is occupied by Bigwin Inn, one of Canada's finest and most distinctive summer resorts which provides wonderful facilities for golf, tennis, lawn bowling, boating, fishing, sailing, tramping and riding in the clean, bracing, pine scented air.

Bigwin Inn is operated on the American plan, board with room, and meals being provided at a nominal rate of $7.50 per person per day. This rate includes ferry trip from Norway Point, golf and tennis privileges as well as the Semi-Annual Banquet.

One of the advantages of Bigwin Inn is its spaciousness. The main building contains the hotel offices and the great rotunda or lounge, comfortably and luxuriously furnished. This room has a high, heavily-beamed ceiling under which a



Detailed Transportation Information

Railway Tickets and Fares:

Standard Summer Tourist tickets should be purchased direct to Bigwin Inn, Ontario; via Toronto and Huntsville. The rates for these tickets are lower than convention rates, and they are good for 10 days.

Special Train From Toronto:

Arrangements are being made for special train leaving Toronto at 12 noon Tuesday the 25th arriving Bigwin Inn before dinner. Arrangements should be made by chapters chartering special Pullmans to have these switched to A. S. H. V. E. Bigwin Special train via Canadian National Railway.

Railway and Departures and Connections:

Trains from practically all centers except Pittsburgh arrive in Toronto between 7:30 and 9:00 A. M. Eastern Standard Time, leaving three or four hours for sightseeing, shopping, *etc.* The train from Pittsburgh, via Buffalo arrives at 11:40 A. M. and A. S. H. V. E. Bigwin Special will be held for its arrival if it should be late.

The latest trains connecting with A. S. H. V. E. Bigwin Special from various points are as follows:

Boston—	B. & M.	—Via Montreal—9 a.m.	Monday.
Buffalo—	L.V.Ry.	— 7:45 a.m.	Tuesday.
	M.C.R.	— 8:00 a.m.	"
Cleveland—	N.Y.C.	— 11:35 p.m.	Monday.
Chicago—	G.T.R.	— 5:30 p.m.	"
	N.Y.C.	— 5:40 p.m.	"
Detroit—	G.T.R.	— 11:30 p.m.	"
	M.C.R.	— 12:10 a.m.	Tuesday.
New York—	L.V.R.	— 6:25 p.m.	Monday.
	N.Y.C.	— 8:35 p.m.	"
Philadelphia—	L.V.R.	— 6:15 p.m.	"
	Penna.	— 8:25 p.m.	"
Pittsburgh—	P. & L. E.	— 11:30 p.m.	"

Trip from Toronto is over the Canadian National (Grand Trunk) Railway and through car service may be had by using their connections in the United States.

Time:

The city of Toronto is on Eastern Daylight Saving time but all railways and Bigwin Inn are on Eastern Standard Time.

Motorists:

Motorists may enter Canada via Montreal from Northern New England, via Ogdensburg, N. Y., and Prescott, Ontario; or Clayton, N. Y., and Gananoque, Ontario from the East; via Lewiston, N. Y., Niagara Falls or Buffalo from the East and South. From the South and West, motorists may cross Lake Erie by ferry from Erie, Pa, or from Cleveland to Port Dover or Port Stanley respectively. They may also enter at Detroit, Mich, or Port Huron. Also they may enter through Sault Ste. Marie, Mich.

From all these points of entry, except Sault Ste. Marie, paved roads lead to Toronto and no difficulty is experienced in finding these roads. The road from Toronto to Norway Point is 141 miles, 93 miles of which is paved while 25 miles is good macadam road and from Bracebridge, Ontario, the balance of the road is winding gravel road which, although hilly and narrow is kept in good condition during the summer.

Motoring distances to Toronto are as follows: Atlantic City, 579; Boston, 570; Buffalo, 107; Chicago, 517; Cincinnati, 505; Clayton, N. Y., 181; Cleveland, 295; Detroit, 242; Erie, 196; Indianapolis, 566; Kansas City, 1,091; Louisville, 640; Minneapolis, 983; Montreal, 347; Niagara Falls, 84; Ogdensburg, N. Y., 223; Philadelphia, 518; Pittsburgh, 350; Port Huron, Mich., 186; Washington, D. C., 524.

All motorists except those coming through Sault Ste. Marie should come to Toronto where an information booth will be in charge of Ontario chapter members.

From Sault Ste. Marie a good macadam road leads, via Sudbury and North Bay to Huntsville and Norway Point. Norway Point is the ultimate motor destination where individual garage space is available for about 80 cars. Free ferry service is being provided across the lake from here to the hotel on Bigwin Island, a distance of one mile.

Customs and Immigration:

No trouble should be experienced in connection with customs entering Canada. Motor cars are admitted on 90 day touring permits free.

Aliens or naturalized U. S. citizens should take the necessary precautions upon leaving the United States to have the necessary papers to insure their re-admittance.

Road Maps:

Motorists who propose to spend extra time touring in Ontario should write to the Department of Public Highways, Parliament Buildings, Toronto, Ont., for road maps, which, although sold for 50c each, are sent free to intending tourists.

Air and Coach Services:

Daily air and coach services are in operation between Montreal, Buffalo, Detroit, and Toronto. Definite information may be obtained by writing to the Chairman of the Meeting Arrangements Committee at 25 Bloor St. West, Toronto 5, Ontario.

surrounding gallery leads to quiet and inviting alcoves for reading, writing and card playing.

The sleeping apartments are in the East and West Lodges to the rear of the main building and connected with it by cement-paved, roofed passageways.

The dining room is a large, bright, circular room, opening on the Venetian Terrace, located right at the water's edge. Away from the main building and Lodge, near the water's edge, is the Pavilion and boat house, an attractive, glass enclosed building where all entertainment functions are held.

To reach Bigwin Inn conveniently, trains run from all points in the United States to Toronto and daily service over the Canadian National Railways, bringing the visitor to the Lake-of-Bays via Huntsville. The traveller leaves the train at Huntsville and steps on to a steamer which continues the journey to Bigwin Inn through the beautiful Fairy and Peninsula Lakes and Lake-of-Bays.

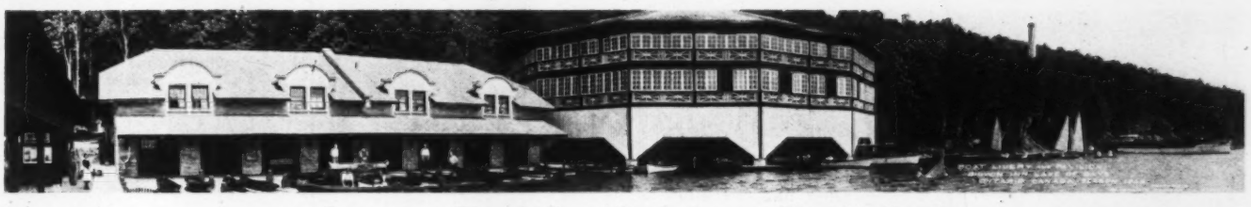
Those members of the Society who plan to come to Canada by automobile have a choice of two routes, an all motor route to Norway Point on the Lake-of-Bays or they may leave their cars in Toronto and join the others and make the 140 mile trip to Bigwin Inn on the special train leaving Toronto Tuesday, June 25, at 12 o'clock noon.

The various Chapters of the Society have appointed special Committees to handle transportation arrangements by train to Bigwin Inn and it is expected that special cars from New York, Philadelphia, Detroit, Chicago, Kansas City and other Chapter cities will reach Toronto, Tuesday morning, June 25, and be attached to the Bigwin Inn Special.

At Kansas City, Nate W. Downes is arranging the travel route for Kansas City Chapter members. In New York, E. J. Ritchie has sent a letter to each Chapter member urging them to come to Bigwin Inn. Pres. H. G. Thomas of Chicago has sent out a circular letter to Illinois Chapter members, urging them to turn out for the Canadian meeting. F. D. Mensing is handling all travel arrangements for the Philadelphia Chapter. T. J. Hester is providing all St. Louis members with information about the Bigwin Inn trip.

The Semi-Annual Meeting of 1929 presents a splendid opportunity to spend some time amid new surroundings, enjoy the technical sessions, June 26 to 28, and meet members from many parts of North America.

The Ontario Chapter members have worked hard to prepare a big meeting for Bigwin Inn and hope that every one who can, will Come to Canada for a pleasant few days at the end of the month.



PAVILION AT WATER'S EDGE WHERE SESSIONS WILL BE HELD

Program of Semi-Annual Meeting

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Bigwin Inn, Lake-of-Bays, Ontario, Canada

June 26 to 28, 1929

TECHNICAL

Wednesday, June 26

8:30 a.m.—Registration.

9:30 a.m.—Greeting by Ontario Chapter President.
Response by Pres. Thornton Lewis.
The Measurement of Air Velocity, by Prof. J. H. Parkin.
Over-all Heating Efficiency of the Research Residence Warm Air System Analyzed, by Prof. A. P. Kratz and J. F. Quereau.
Air Conditioning System of a Detroit Office Building, by H. L. Walton and L. L. Smith.
Report of Committee on Code for Testing and Rating Unit Heaters, by D. E. French, Chairman.

Thursday, June 27

9:30 a.m.—Report of Committees on Interpretation of Code for Rating Low Pressure Heating Boilers, by L. A. Harding, Chairman.
Determining Dust Quantities in Air, by Prof. F. B. Rowley and John Beal.
Capacity of Radiator Supply Branches for One and Two-Pipe Systems, by F. C. Houghten, M. E. O'Connell and Carl Gutberlet.
Pipe Sizes for Hot Water Heating Systems, by Prof. F. E. Giesecke and E. G. Smith.
Report of Guide Publication Committee, by S. R. Lewis, Chairman.

Friday, June 28

9:30 a.m.—Report of Committee on Code for Heating and Ventilating Garages, by E. K. Campbell, Chairman.
Time Lag as a Factor in Heating Engineering Practice, by James Govan.
Over-all Heat Transmission Coefficients as Determined by Test and by Calculation, by F. B. Rowley, A. B. Algren and J. L. Blackshaw.
Five Suggested Methods of Appraising Insulations, by Paul D. Close.
Report of Advisory Committee on Heating and Ventilating Exposition, by H. P. Gant, Chairman.

ENTERTAINMENT

Tuesday, June 25

12:00 a.m.—Special train leaves Toronto for Bigwin Inn via Huntsville.
6:00 p.m.—Arrive Bigwin Inn—Dinner from 6:30 to 8:00 p.m.
8:15 p.m.—Special program for Ladies—Introduction of Chapter Officers in the Rotunda.
9:00 p.m.—Informal reception and dancing in the pavilion. Motion pictures in the Rotunda.

Wednesday, June 26

8:30 a.m.—Registration in the pavilion.
10:30 a.m.—Special hiking party for ladies to explore Bigwin Island.
1:30 p.m.—Special Boat trip around Bigwin Island and Lake-of-Bays for ladies.
2:30 p.m.—Golf tournament for Research Cup.
8:30 p.m.—Amateur Theatricals by cast of Ontario Chapter's members followed by Masquerade Ball in the Ballroom.

Thursday, June 27

9:30 a.m.—Golf tournament for ladies.
2:30 p.m.—Bridge party and tea for ladies.
7:00 p.m.—Semi-Annual Banquet in main dining room followed by dancing.

Friday, June 28

2:00 p.m.—Golf Match.
Tennis Tournament.
Lawn Bowling.
International Bang-and-Go-Back Motor Boat Racing Contest (each Chapter will have a boat).
Log Rolling Contest by local talent.

COMMITTEE ON ARRANGEMENTS

M. Barry Watson, General Chairman; Arthur Leitch, Entertainment; M. F. Thomas, Reception; A. J. Dickey, Finance; E. B. Sheffield, Transportation; and Edward M. Dolan, Publicity.

First International Heating and Ventilating Exposition Making Splendid Progress

WHEN the First International Heating and Ventilating Exposition opens in the Commercial Museum, Philadelphia, January 27, 1930, that large building will house one of the most diversified and comprehensive exhibits of Heating and Ventilating equipment that could be imagined.

In the list of manufacturers, who have already reserved space, will be found leaders of the industry and it is evident that boilers, radiators, pumps, valves, stokers, unit heaters, oil burners, instruments, controls, fans, motors, temperature regulators, air heaters, water heaters, air conditioning equipment and insulation, will be outstanding among the equipment shown.

Heating devices of all kinds including coal, gas, and oil fired units as well as equipment for district heating and warm air heating, are to be featured by representative groups.

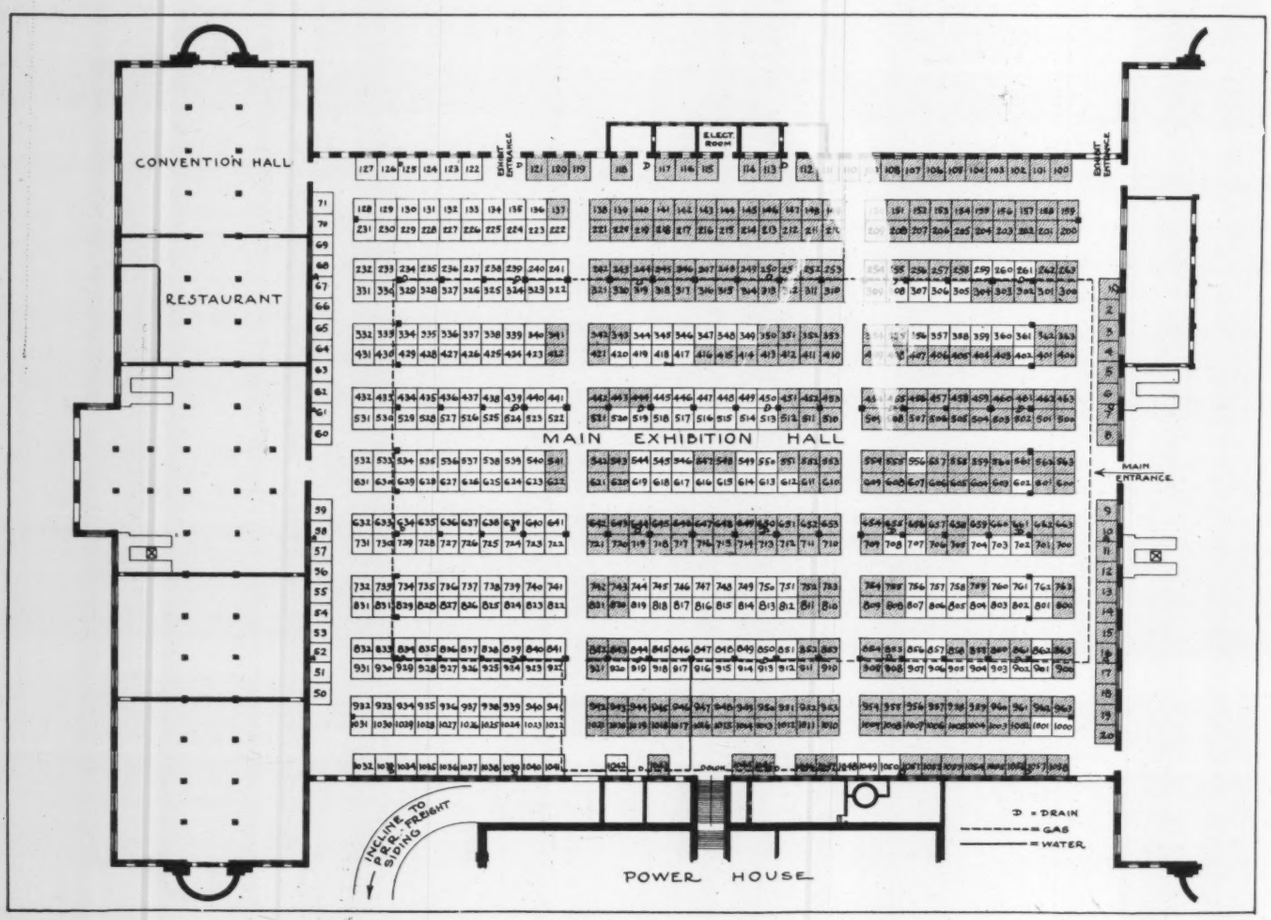
Even though several months will elapse before the show opens the accompanying diagram and list of exhibitors shows how much of the space has been requested up to May 15.

For the Exposition, President Thornton Lewis has appointed the following Advisory Committee:

H. P. Gant, Chairman, Philadelphia.
E. B. Langenberg, St. Louis.
J. I. Lyle, Newark, N. J.
J. F. McIntire, Detroit.
F. R. Still, New York City.
H. L. Whitelaw, New York City.
E. K. Webster, Camden, N. J.
H. C. Murphy, Louisville, Ky.
A. S. Armagnac, New York City.
D. S. Boyden, Boston.
A. C. Edgar, Philadelphia.
W. H. Carrier, Newark, N. J.
Roswell Farnham, Buffalo, N. Y.
C. V. Haynes, Philadelphia.

In addition to this, a Co-operating Committee composed of the leading executives of various allied organizations will work with the Advisory Committee. Those who have already consented to serve are:

Floor Plan of Exposition Hall



Shaded Area Indicates Space Reserved for First International Heating and Ventilating Exposition
Commercial Museum, Philadelphia, Pa., January 1930

O. H. Fogg, President, American Gas Association.

W. C. Hanson, President, National Pipe and Supplies Assn.

Prof. A. J. Wood, President, American Society of Refrigerating Engineers.

John W. Meyer, President, National District Heating Assn.

E. M. Fleischmann, President, American Oil Burner Assn.

H. T. Richardson, President, National Boiler and Radiator Manufacturers Association.

R. T. Creviston, Manager, Plumbing and Heating Industries Bureau.

C. E. Hall, Director, National Warm Air Heating Assn.

On the accompanying list will be found the firms that have contracted for exhibit space:

Air Control Corp. of N. Y.
Alexander Bros., Inc.
American Gas Association.
American Gas Products Corp.
American Radiator Co.
Ames Pump Co.
Armstrong Machine Works.
Barnes & Jones.
Bishop & Babcock Sales Co.
Brown Instrument Co.
Bryan Steam Corp.
Bryant Heater & Mfg. Co.
Carrier Engineering Corp.
Chicago Pump Co.
Cochrane Corp.
Columbia Burner Co.
Combustion Specialties Corp.
Cooling & Air Conditioning Corp.
Copper Radiator Sales Corp.
Coppus Engineering Corp.
Crane Co.
Direct Control Valve Co.
Domestic Engineering Pub.
Domestic Stoker Co.
Dunham, C. A., Co.
Farnsworth Co.
Frank, O. E., Heater & Eng. Co.
General Gas Light Co.
Grinnell Co., Inc.
Hardinge Bros., Inc.
Hart & Hutchinson Co.
Hartzell Propeller Co.
Heating & Ventilating Magazine.
Heating Journal, Inc.
Heggie Simplex Boiler Co.
Hill, E. Vernon, Co.
Hoffman Specialty Co., Inc.
Illinois Engineering Co.
Iona Ventilator Co.
Johnson Service Co.
Johnson Co., S. T.
Kelly Brass Works.
Kewanee Boiler Corp.
Kieley & Mueller, Inc.
Korfund Co., Inc.
Leslie Co.
Marsh, James P., & Co.
McDonnell & Miller.
McQuay Radiator Corp.
Mears-Kane-Ofeldt, Inc.
Mercoid Corp.
Minneapolis-Honeywell Reg. Co.
Modine Mfg. Co.
Molby Boiler Co.
Multicell Radiator Co.
Nash Engineering Co.
National Regulator Co.
Nesbitt, John J., Inc.
Park-Cramer Co.
Richmond Radiator Co.
Rome Brass Radiator Co.
Sarco Co., Inc.
Spencer Heater Co.
Star Expansion Bolt Co.
Strandwitz & Scott, Inc.
Sweet & Doyle Fdry. & Mach. Co.
Smith Twin Tubular Boiler Co.
Schade Valve Mfg. Co.
Taco Heaters, Inc.
Time-O-Stat-Controls Co.
U. S. Radiator Corp.
Vinco Co., Inc.
Warren Webster & Co.
Westinghouse Elec. & Mfg. Co.
Wilson Bros.
Wood Conversion Co.
Wright-Austin Co.
York Heating & Ventilating Corp.

Local Chapter Meetings

Kansas City Chapter

April 8, 1929. The April meeting of the Kansas City Chapter of the American Society of Heating and Ventilating Engineers was held Monday evening, April 8, at the Ambassador Hotel, Kansas City, with an attendance of 26 members and guests.

Professor Sluss, head of the mechanical engineering department at the University of Kansas, invited all the members to attend a conference pertaining to heating and sanitation to be held at the Engineering School April 9, 10 and 11.

John F. Hale of Chicago, Ill., was the speaker of the evening and gave a very interesting talk on the progress made in heating in recent years, which was enjoyed by all.

Following Mr. Hale's address the meeting was adjourned.

Michigan Chapter

May 16, 1929. Sixty members and guests of the Michigan Chapter were present for the May Meeting at The Hawthorne Valley Golf Club. This meeting was held for the dual purpose of electing officers for the coming year, and bringing together the members of the Chapter and their friends who enjoy golf.

V. Haynes, a member of the Council, was a guest speaker and gave an interesting talk, chiefly concerning the good which the members at large can do by offering constructive criticism and suggestions to the editors of The Guide.

After an excellent dinner, Pres. W. A. Rowe called the meeting to order and the usual reports of the officers and chairmen of committees were submitted. In addition, W. G. Boales and R. K. Milward spoke regarding the Society's Summer Meeting to be held at Bigwin Inn.

Mr. Soderburg then announced the golf scores and the tournament winners were Messrs. R. F. Connell, and R. Deppmann. Messrs. Brown, Shea and McColl had tie scores for third place.

After the announcement of the winners, ballots were cast and the following officers were elected for the coming year: *President*, W. G. Boales; *Vice President*, E. E. Dubry; *Treasurer*, R. K. Milward; *Secretary*, E. H. Clark.

Board of Governors: L. L. McConachi, W. J. Whelan and H. M. Stephen.

Following the election of officers, W. A. Rowe, the retiring president, relinquished the chair to the incoming president, W. G. Boales, and this ceremony was followed by talks from the other newly elected officers.

Upon the motion of W. B. Johnston, a rising vote of thanks was given to the retiring president, W. A. Rowe, for the splendid work which he has done during the past twelve months.

April 16, 1929. The April meeting of the Michigan Chapter was held in the new Fisher Building, and was considered the most successful meeting ever held by this chapter, dinner being served in the Dining Room on the Concourse to 142 members and guests.

Pres. W. A. Rowe introduced Herbert Ziel of Albert Kahn, Inc., who took part in the design of the ventilating systems in the Fisher Building, and who was the first speaker of the evening. Mr. Ziel enumerated the different heating and ventilating systems used and brought out the fact that although the equipment is scattered over the entire building, the control of this equipment is centralized at one point. This building contains a bank, garage, theatre, private dining rooms, cafeteria, arcade, pedestrian tunnel connecting the Fisher Building with the General Motors Building, stores, exclusive shops, rest rooms, x-ray departments, a wing devoted to the medical profession, an internationally known broadcasting station, as well as office space, so that the ventilating engineers of the building had many interesting problems to solve.

After Mr. Ziel's address, G. D. Winans of the Detroit Edison Co. gave a description of the problems met in furnishing steam to the Fisher Building. He stated that steam is supplied not only to the Fisher Building, but to the General Motors and Argonaut Buildings, which are grouped together. Mr. Winans pointed out that they had determined by experience that when the steam load in the various parts of the building was staggered, instead of supplying all parts at the same time, the cost of the steam demand was reduced.

The next speaker of the evening was Fred Johnson of Johnson-Larsen & Company, heating and ventilating contractors of Detroit, who installed the heating and ventilating equipment in the Fisher Building. He discussed the heating and ventilating

systems in use, starting with the steam supply, and carrying it through the entire cycle. Mr. Johnson pointed out that 20 supply fans, 15 miles of pipe and 35 carloads of material were required for this building, and that 40 unit heaters were required for the garage alone. Both floor mounted and overhead unit heaters are used. Mr. Johnson also spoke of the method of returning the condensation to the boilers at the central heating plant, and stated that there is a float box in the return line which allows the condensation to get back to the boilers in a constant trickle, rather than in slugs of water.

Among the unique features to be found in the heating and ventilation equipment in the Fisher Building are the copper radiators of the convection type throughout the entire building. These radiators are equipped with direct acting temperature control valves. The zoning system of heating is used with control valves on the steam risers. Any or all parts of the building may be furnished with steam at will.

The Fisher Theatre, which is located in this building, has been treated as an individual unit. During the winter operating season, the air supply is through mushrooms in the floor and the exhaust is through the ceiling. For summer operation, however, the entire air flow is reversed, so that the cooled air is supplied at the ceiling and exhausted through mushrooms in the floor. This reversing of the air flow is accomplished by air switches.

All of the steam risers in this building are made up of welded pipes. There are no couplings or flanges, except where they are necessary from an operating standpoint. Mr. Johnson brought out the fact that the piping erection gang followed the steel erectors when the building was being fabricated. A sleeve was placed around the piping at the different floor levels and then the floors were poured. After the sleeves were withdrawn, welding crews burned openings in the risers for the branch connections, etc.

After Mr. Johnson's interesting address, a motion picture showing how pipe is welded on the job, was presented by W. G. Boales. After the picture an inspection of the machinery room in the sub-basement was made.

President Rowe called attention to the International Heating and Ventilating Exposition which is to be held in Philadelphia, January 27-31, 1930, and pointed out that manufacturers were taking available space rapidly.

As the annual election of officers is to take place at the May meeting, President Rowe appointed a nominating committee, consisting of E. Harrigan, chairman, W. E. Degan and S. M. Wilde, requesting that this committee select the candidates for the various offices and submit the list to the Secretary on or before May 1.

W. G. Boales called attention to the semi-annual meeting to be held at Bigwin Inn, outlining the various attractions to be found at this meeting.

Western New York Chapter

April 15, 1929. M. F. Rather of Cleveland, discussed Modern Applications of Automatic Temperature Regulation and Humidity Control at the April meeting, held at the Elks Club, Buffalo, and illustrated his talk with slides of pictures of various types of temperature regulation apparatus.

Mr. Rather stated that temperature regulation may be divided into three subdivisions according to the method involved, namely, the pneumatic, the electric and the self-contained thermostat. He also discussed what he called the supersensitive thermostat used in connection with extended surface heaters.

Slides were shown illustrating the use of the thermostats in connection with hot-blast systems, warm-air systems, combination split systems and unit systems of heating, and the flexibility possible with the proper use of thermostats was pointed out.

Interesting data were presented relative to the economy of operation of heating plants resulting from automatic regulation. Mr. Rather discussed the dual or two-temperature thermostat by means of which buildings or sections of buildings can be segregated and operated at different temperatures.

The subject of humidity control and the apparatus used therefor, was presented in an entertaining manner by the speaker.

Sixty-five members and guests attended the meeting which lasted until nearly midnight. President Dyer urged every one to attend the Society's Summer Meeting at Bigwin Inn, Lake-of-Bays, Ontario, and appointed Cecil Farrar to head a committee to foster interest in this meeting.

Plans of the Entertainment Committee for the coming year were reported by Joseph Davis, Chairman.

Minnesota Chapter

April 8, 1929. The April Meeting was held at the Men's Union Building, University of Minnesota, Minneapolis. After a very enjoyable dinner, the speaker of the evening, Earl Evleth of the Bastian Blessing Co., Chicago, Ill., delivered an illustrated talk on the subject of Welding of Piping in the Heating, Ventilating and Plumbing Fields. The extent of the interest in the art of welding, as applied particularly to heating and plumbing, was evidenced by the number of guests present at the meeting.

Pacific Northwest Chapter

April 25, 1929. The monthly meeting of the Pacific Northwest Chapter of the American Society of Heating and Ventilating Engineers, which was preceded by a dinner, was held at the New Washington Hotel, Thursday, April 25, at 6:30 p.m., with C. F. Twist presiding.

The entire meeting was devoted to a discussion of the proposed heating and ventilating code for the State of Washington. The report of the Code Committee was read by the secretary, and after a lengthy discussion, it was decided to refer the report again to the committee with suggestions that the items of recirculation, fresh air intake and air changes in locker rooms be further studied and reported on at the next meeting.

Secretary Eastwood informed the members that he personally as representative of the *American Society of Mechanical Engineers* upon the Assembly of American Engineering Council, had been requested to serve as State Committeeman for Washington to procure adoption and practice of the National Traffic and Safety Code. Cooperation of the Chapter was requested and the presentation cordially received.

It was decided to hold the Annual Meeting of the Chapter late in May or early in June and to have a special program which will be announced at a later date.

Philadelphia Chapter

April 11, 1929. J. I. Lyle, past-president of the Society, and vice-president and general manager of the Carrier Engineering Corp., was the speaker of the evening at the April meeting held at the Engineers' Club, and gave an unusually interesting talk on the air conditioning system in the U. S. House of Representatives, Washington, D. C. After the discussion which followed Mr. Lyle's talk, a rising vote of thanks was extended to him, upon motion of Mr. Mensing.

It was voted to hold the May meeting and dinner at the Plymouth Country Club, after which an inspection of the Frost Research Laboratory would be made and where guides would be furnished to conduct the members through the laboratory.

The Treasurer's report as presented by Mr. Sanbern, was approved, and a Nominating Committee was elected consisting of R. E. Jones, Chairman, F. D. Mensing, H. P. Gant, J. D. Cassell and R. V. Frost.

Mr. Mensing discussed plans of the Chapter for attendance at the Summer Meeting of the Society June 26-28, 1929, at Big-

win Inn., Lake-of-Bays, Ontario, Canada, explaining that a special car for Philadelphia members would be run over the Lehigh Valley Railroad to Toronto. Further details are to be furnished later.

R. C. Bolsinger reported that the Benjamin Franklin Hotel had been selected as headquarters for the Annual Meeting of the Society in Philadelphia in 1930.

A Committee, appointed by the President, composed of H. P. Gant and F. D. Mensing, prepared the following resolution:

"The members of the Philadelphia Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, were truly saddened and grieved to learn of the death of their associate and fellow member Leonard G. Paine, April 11, 1929, at Philadelphia.

Leonard Paine was one of those rare, but highly appreciated gentlemen whose courteous, pleasant and happy disposition made and held many loyal friends.

Be it further resolved by the Philadelphia Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, that this organization has lost a valuable member and a true friend whose cheery smile and friendly hand clasp will be missed by all of us.

Be it further resolved that this Chapter extends its deep and sincere sympathy to the wife, family and friends of our deceased member in their sorrow, and

Be it further resolved that a copy of these resolutions be sent to the wife and family of Leonard G. Paine, and that they be incorporated in the minutes of this Chapter."

Pittsburgh Chapter

April 8, 1929. The Pittsburgh Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS held its regular monthly meeting at the William Penn Hotel on April 8, with the usual dinner preceding the meeting.

The Chapter was very fortunate in having as speaker of the evening Thornton Lewis, president of the Society, Philadelphia, who talked on the operations of the Society and plans for the coming year. This subject was of vital interest to every member and also those guests who were interested in the workings and progress of the Society in general.

After a very enjoyable evening the meeting was adjourned.

March 11, 1929. The March meeting of the Pittsburgh Chapter of the Society was held at the William Penn Hotel where 30 members and guests were in attendance for both the dinner and meeting.

Pres. H. Lee Moore was requested to again explain the limited membership plan for chapters.

A representative of the Canadian National Railway was present who told of the railway connections to Bigwin Inn, Ontario, where the Semi-Annual Meeting will be held in June.

Following the discussion on the routes to Bigwin Inn, J. M. Robb, Herman-Nelson Corp., Moline, Ill., gave a very interesting talk on unit ventilation, explaining the history, development and present day usage of this method of heating and ventilating.

February 11, 1929. The members and guests of the Pittsburgh Chapter of the Society met at the William Penn Hotel, February 11, 1929, for their regular dinner and meeting, which was attended by 24 people.

After the usual routine business and reports of committees, Pres. H. Lee Moore called upon several men who had attended the Annual Meeting in Chicago.

F. C. Houghten, director of the Research Laboratory of the Society, gave an outline of the paper Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, which he presented at the Annual Meeting. He also mentioned the importance of the boiler rating code which was adopted.

F. C. McIntosh spoke on the changes in the JOURNAL policy and gave some details of new arrangement with HEATING, PIPING AND AIR CONDITIONING.

R. E. Hall, director of Hall Laboratories, Inc., Pittsburgh, gave an interesting talk on some characteristics of corrosion and of the boiling of water. He discussed the effect of O_2 and CO_2 on corrosion and the effect of calcium and other salts on the boiling of water, which was followed by a discussion in which a large number participated.

January 7, 1929. Thirty-four members and guests of the Pittsburgh Chapter attended the meeting and dinner at the William Penn Hotel.

President H. Lee Moore introduced each of the newly elected officers, and then gave a short talk on activities and prospects for the coming year.

F. C. Houghten, Director of the Research Laboratory of the Society, discussed the topic of smoke abatement activities in the city saying that other Chapters have taken active part in their similar city problems. Mr. Houghten was appointed as a committee of one to frame a co-operative resolution offering all available assistance to the Pittsburgh Chamber of Commerce.

Percy Nicholls, who is in charge of the Fuel Section of the U. S. Bureau of Mines, then brought up the subject of the Code for the Rating of Low Pressure Boilers. This Code was adopted by an almost unanimous vote at the Annual Meeting of the Society in Chicago, January 28-31, 1929, following an interesting discussion in which many members and others concerned with the matter, participated. Prof. L. E. Seeley, Yale Scientific School, and Mr. Houghten, led the discussion which concluded the meeting.

St. Louis Chapter

The St. Louis Chapter of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is cooperating with the David Rankin School of Mechanical Trades, St. Louis, in formulating a lecture course in heating and ventilating which will be given during the night school session starting in October, 1929. Paul Sodemann has been appointed by the local Chapter of St. Louis as chairman of the Committee which has selected a teacher who is now working with the Committee on the course of instruction.

Engineering Congress

Arrangements for the reception of 100 of Europe's most distinguished engineers and scientists, who will arrive here during the summer en route to the World Engineering Congress at Tokio, have been placed in charge of Roy V. Wright, president of the United Engineering Societies, as Chairman of the New York Reception Committee, according to announcement yesterday from Maurice Holland, Executive Secretary of the American Committee of the Congress, of which Dr. Elmer A. Sperry is Chairman. Mr. Wright will be aided by a committee of New York Engineers.

It is expected that the foreign engineers will arrive in separate delegations of approximately forty each from Great Britain and Germany, and the balance from Sweden, Denmark, France and Italy, probably during August and September.

The foreign delegations will sail from the Pacific coast for Japan about the time that the American delegation, which is now composed of 235 engineers and their families from all parts of the country, sails from San Francisco.

With Mr. Wright on the New York Reception Committee are: Bancroft Gherardi, J. V. W. Reynders, F. R. Low, C. O. Mailloux, A. W. Berresford, H. Foster Bain, F. L. Hutchinson, Calvin W. Rice and George T. Seabury. Offices will be set aside for the visitors in the headquarters of the American Committee of the World Engineering Congress, 29 West 39th Street.

Hotel Headquarters Selected for Annual Meeting 1930

The 35th Annual Meeting of the Society to be held in Philadelphia, Pa., January 27 to 30, 1930, will be conducted under the direction of committees from the Philadelphia Chapter.

President Edgar of the Philadelphia Local recently announced that the General Chairman of the Committee on Arrangements would be R. C. Bolsinger. Word from Chairman Bolsinger indicates the selection of Hotel Headquarters, the Benjamin Franklin at 9th and Chestnut Sts., for the four day meeting.

Technical sessions will be so arranged that the visiting members and guests will have ample opportunity to attend the first International Exposition of Heating and Ventilating, which will be held at the Commercial Museum during the same week as the Society's Meeting.

Death of Leonard G. Paine

Leonard G. Paine of Philadelphia, one of the most beloved members of the Society, died on April 11, 1929.

Mr. Paine was one of those rare but highly appreciated gentlemen whose courteous, pleasant and happy disposition made and held many loyal friends.

Mr. Paine was born on April 30, 1863, at Farmington, Conn., and became a member of the Society in 1920.

The American Society of Heating and Ventilating Engineers has lost a valuable member and a true friend, whose cheery smile and friendly hand clasp will be missed by all who knew him.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the name of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 31 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by July 2, 1929, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary, immediately after election.

	REFERENCES	
	Proposers	Seconders
BERNHARD, GEORGE, Htg. Engr., George Bernhard Htg. Co., Inc., 1007 Church Ave., Brooklyn, N. Y.	F. W. Phillips, Jr. B. F. Griffin	E. W. Mandeville W. Erlich
BLUME, FREDERICK JOHN JR., Sales Engr., American Radiator Co., 40 West 40th St., New York, N. Y.	Edw. B. Johnson T. W. Reynolds	O. O. Oakes J. Pfuhler
BOZEMAN, RICHARD W., Student, University of Kentucky, Lexington, Ky.	F. Paul Anderson John H. Holton	Donald E. French Lester S. O'Bannon
CARLSON, EVERETT E., Br. Mgr., The Powers Regulator Co., 1010 Louderman Bldg., St. Louis, Mo.	J. Lawrence DeNeille E. R. Barnes	Alvin Eichler Thomas Gale
CORNELIUS, FRANK HUDSON, Cornelius Engrg. Co., 7400 Idlewild St., Pittsburgh, Pa.	Edwin C. Evans P. A. Edwards	Thomas Chester H. Lee Moore
FREEMAN, ALTON M., Sales Engr., H. M. Miller, 6089 Plankinton Bldg., Milwaukee, Wis.	Wm. F. Noll H. M. Miller	W. H. Wilson H. W. Ellis
GIFFORD, EDMUND WARLAND, Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.	J. I. Lyle W. H. Carrier	L. L. Lewis Herman Worsham
GILLIAM, OLIVER FULGHAM, Sales Engr., York Htg. & Vtg. Corp., 205 W. Wacker Dr., Chicago, Ill.	Thornton Lewis Donald E. French	James A. Carey H. P. Gant
GRANT, WALTER ADAMS, Carrier Engrg. Corp., 850 Fhelinghuysen Ave., Newark, N. J.	L. L. Lewis M. S. Smith	A. E. Stacey, Jr. W. H. Carrier
GURNEY, EDWARD HOLT, Pres., The Gurney Foundry Co., Ltd., 500 West King St., Toronto, Ont., Can.	E. B. Sheffield Melvern F. Thomas	M. Barry Watson Harry H. Angus
HILLEN, ALVIN G., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.	W. H. Carrier J. I. Lyle	Herman Worsham L. L. Lewis
HILLEN, WILLIAM GEORGE, Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.	W. H. Carrier J. I. Lyle	L. L. Lewis F. Paul Anderson
HOAGLAND, WALTER H., Sales Mgr., House Htg. Div., Laclede Gas Co., 1017 Olive St., St. Louis, Mo.	R. M. Rosebrough C. A. Pickett	E. B. Langenberg Chas. G. Buder
HOOD LESLIE, Sales Engr., Trane Co. of Can., 439 King St., W., Toronto, Ont., Can.	R. W. M. McHenry Grant E. Cole	Melvern F. Thomas Jas. S. Paterson
KLUBE, JOHN O., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.	J. I. Lyle W. H. Carrier	L. L. Lewis A. E. Stacey, Jr.

MEHNE, CARL A., Engr., Richardson & Boynton Co., 260 Fifth Ave., New York, N. Y.	D. Rait Richardson John A. Doherty	E. A. Munro Henry W. Hochuli
MURPHY, JOSEPH R., Sales Mgr., Taco Heaters, Inc., 342 Madison Ave., New York, N. Y. (Advancement.)	E. S. White J. C. McDonald	F. P. Hitchcock W. A. Russell
NAROWETZ, LOUIS LUDWIG, JR., Secy. & Active Head, Narowetz Htg. & Vtg. Co., 1711 Maypole Ave., Chicago, Ill. (*Advancement*)	E. P. Heckel C. W. DeLand	Carl W. Johnson
NOLAN, JAMES JOSEPH, JR., Carrier Engrg. Corp., 850 Frelinghuysen Ave., Newark, N. J.	J. I. Lyle W. H. Carrier	L. L. Lewis A. E. Stacey, Jr.
O'NEILL, JAS. WALTER, Ch. Engr., The Trane Co. of Canada, 439 King W., Toronto, Ont., Can. (Advancement.)	R. W. M. McHenry W. R. Blackhall	E. B. Sheffield Jas. S. Paterson
PORZEL, JOSEPH, Vice-Pres., Multicell Radiator Corp., Buffalo & Lockport, N. Y.	C. H. Love W. G. Fraser	H. F. Hutzel L. A. Harding
RIES, LESTER S., Supt. of Bldgs., University of Chicago, 5750 Ellis Ave., Chicago, Ill.	J. A. Cutler H. M. Hart	J. S. Jenson Jas. C. Matchett
SAWHILL, R. V., Editorial Director, Domestic Engineering Publications, 1900 Prairie Ave., Chicago, Ill.	Samuel R. Lewis John F. Hale	A. C. Willard Alfred Kellogg
SCOLLAY, JOHN A., York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y.	H. Berkley Hedges Thornton Lewis	H. P. Gant Jas. V. Cavileer
SMITH, RUSSELL J., St. Louis Repr., Modine Mfg. Co., 2228 Washington Ave., St. Louis, Mo.	L. Steckhan E. A. White	J. Lawrence DeNeille E. R. Barnes
STEVENSON, MERLE E., Stevenson Heating Co., Richmond, Ind.	G. C. Mitchell (ASME) Wilfred Nevue	Prof. A. M. Charles T. H. Saville
STROCK, CLIFFORD, Asst. Editor, Heating & Ventilating Magazine, 521 Fifth Ave., New York, N. Y.	L. R. Taylor A. S. Armagnac	C. H. B. Hotchkiss Cliff Presdee
TENNANT, RAYMOND J. J., Supervisor, Duquesne Lt. & Allegheny Co. Steam Htg. Co., 435 Sixth Ave., Pittsburgh, Pa.	Chas. W. Wheeler Homer E. Digby	
THOMPSON, WILLIAM JAMES, Sales & Engr. & Advertising, Imperial Iron Corp., Ltd., 250 St. Helens Ave., Toronto, Ont., Can.	W. R. Blackhall Harry H. Angus	Arthur S. Leitch Jas. S. Paterson
WASHINGTON, LAURENCE W., Vice-Pres. & Secy., National Regulator Co., 2301 Knox Ave., Chicago, Ill.	Samuel R. Lewis Geo. M. Getschow	W. M. Brayton C. W. Johnson
WHITE, CHARLES FERBER, Sales Engr., Modine Mfg. Co., 3010 Market St., Philadelphia.	E. Nute Sanbern R. D. Tyler	W. A. Bornemann Franklin W. Wandless
WOODLOCK, WILLIAM M., York Htg. & Vtg. Corp., 149 Broadway, New York, N. Y.	H. Berkeley Hedges Thornton Lewis	H. P. Gant Jas. V. Cavileer

Candidates Elected June, 1929

In the past issues of the Journal of the Society there were posted among the list of Candidates for Membership, 17 candidates for election in the different grades of Membership, whose names have been balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

BAIRD, FLOYD E., Southern Br. Mgr., Trane Co., LaCrosse, Wis.

CUNNINGHAM, NOEL, Engr., Anthracite Operators Conference, 120 Broadway, New York, N. Y.

DORFAN, MORTON I., Mgr., Dust Collecting Dept., Pangborn Corp., Hagerstown, Md.

HELBURN, I. B., Mgr., Air Filter Service Co., 844 Rush St., Chicago, Ill.

HUNTER, VERNE WILLIAM, Supt., Grant Bldg., Inc., 417 Grant Bldg., Pittsburgh, Pa.

KELLOGG, THOMAS MILTON, New York Mgr., Bishop & Babcock Co., 444 Lafayette St., New York, N. Y.

KEPLINGER, WILLIAM LINCOLN, Dist. Mgr., Aerofin Corp., 39 Cortlandt St., New York, N. Y.

LENNON, JOSEPH O., New York Mgr., Ilg Elec. Vtg. Co., 13 Park Row, New York, N. Y.

McILVAINE, JOHN HARMON, Pres., McIlvaine Burner Corp., 749 Custer Ave., Evanston, Ill.

SHARP, FLOYD H., Htg. Contr., Chatfield & Sharp, 304 Pine St., Jamestown, N. Y.

ASSOCIATES

BOLTE, EDWARD ENDICOTT, National Radiator Corp., 2445 N. Keeler Ave., Chicago, Ill.

DOHERTY, RUSSELL, Chicago Br. Mgr., National Radiator Corp., 2445 N. Keeler Ave., Chicago, Ill.

SPAFFORD, LEWIS BURTON, Domestic Engrg. Publications, 1900 Prairie Ave., Chicago, Ill.

JUNIORS

ARKO, FRANK W., University of Minnesota, Minneapolis, Minn.

BLACKSHAW, JOE LOVEJOY, Research Fellow, A. S. H. V. E., Experimental Laboratories, Univ. of Minnesota, Minneapolis, Minn.

KOETZ, LESTER, Salesman, Zion Institutions & Industries, Zion, Ill.

SIMONDS, ABE HOMER, Sales Engr., Carrier Engrg. Corp., 748 E. Washington St., Los Angeles, Calif.

Heating · Piping
and Air Conditioning

EDITORIALS

"Pipe Consciousness"

In the article on "Industrial Piping" which appeared in our May issue, Albert W. Moulder, the author of this article, called piping a system of transportation. Instead of conveying goods, machinery and a variety of products, it conveys steam or liquid for power, heat or some other necessary adjunct to production. Mr. Moulder made the statement that the man who ships heat or energy from a boiler to a machine through a pipe line pays freight at every fitting, joint and bend. He pays for maintenance, depreciation and obsolescence.

In spite, however, of the importance of proper piping, so graphically pictured by Mr. Moulder, many industrial plants pay little attention to the design, installation and maintenance of "industrial piping transportation lines." They select and purchase their prime movers. They procure the machinery essential to their manufacturing process. And they think they have outfitted their plant. It is merely necessary, then, they seem to feel, to connect them up with pipe and start production.

That kind of practice has little regard for the coal pile, for uninterrupted plant operation or for efficiency in production. We have said before in these columns that it is poor economy to generate the various forms of energy efficiently and then waste the savings thus made by inefficient distribution and utilization. And it is possible to waste more than these savings in first cost and in maintenance of improperly designed, improperly installed piping.

We were talking to an engineer recently who runs a fairly large industrial plant. He said that he had never given much thought to piping—never considered the running of a pipe line much more than screwing a few lengths of pipe together. And he added, "Maybe I should, though. Maybe I don't pay enough attention to it."

Indeed he should, and so should every engineer. As Mr. Moulder said, "What is needed is more pipe consciousness."

Air Conditioning for Health

The great American public has been made "conscious" of so many things which American business has to sell that one can well marvel at its absorption capacity—both as to mind and to pocketbook. Advertising's compelling force has put the automobile, the radio and countless luxuries and ideas in a position of sales leadership by making the public "conscious" of their desirability.

There is a "conscious-making" job yet to do, though, with which we of the air conditioning field are concerned—that of making the public "health conscious" in general and "air conscious" in particular.

The average individual is not much inclined to think about his health until he has lost it. The average business executive is not much inclined to think of the health of his employes in relation to the cost of doing business. Thus, any service, device or system which has as its basic appeal the protection of health is, to a large extent, bucking a general apathy. This is a state of affairs that is slowly changing, but it is with us now and represents the direction in which educational efforts must be directed in order to increase the use of air conditioning—the use of it, that is, for a strictly health purpose.

Public Opinion in Engineering

It has been stated by leaders in that field that district heating is expanding rapidly. This was reiterated at the recent district heating school at Purdue University, Lafayette, Indiana, the program of which is reported in this issue.

The object of this editorial is not to analyze district heating but rather to ascertain, if possible, some of the fundamental causes of this expansion so that industrial concerns, many of which are approaching the status of the public utility, may learn and profit thereby.

The building up of friendly relations with the public is recognized by district heating companies as a fundamental duty. One of the exponents of this is J. H. Walker of the Detroit Edison Company, Detroit, Michigan, who explained in his address at the school that district heating companies work with the laws of psyschology and that, while psychological laws differ from physical laws in that they can not be expressed by a formula, they are none the less real. The effects of certain practices in dealing with the public, he said, are absolutely definite and predictable and many of the ill-considered methods are inexcusable. Fair dealing also is not only an ethical principle but also a policy with district heating companies, according to Mr. Walker, and these principles are credited for much of the expansion that is now going on in this field.

A business concern becomes a public utility when it

reaches that condition when its service or products become so valuable that they are no longer a luxury or a casual need but a necessity. What manufacturer or engineer would not welcome the day when it can be said that the public demands his products or his service? He then is a public utility in the degree that he approaches that condition.

What each concern might do about it might be expressed by the following formula:

$$\frac{P \times S}{Si} = A$$

When P equals public opinion; S, degree of service; Si, size of the concern; and A, action to be taken in the matter.

The job of the engineer is, perhaps, more closely associated with production than with public relations. However, whether he be designing a building, producing a utility or operating a plant, the test of his work in the end is public acceptance. He should not disregard this fact. Public opinion of the organization with which he is connected and of the field to which he belongs, therefore, is his concern, and the application of this suggested formula can well be made to his engineering.

Important Conventions

The month of June will find engineers and contractors in the field of heating, piping and air conditioning assembled in several important conventions. District heating engineers will be at Detroit. Heating and piping contractors will be at St. Louis. Refrigerating engineers will be at State College, Pa. Heating and ventilating engineers will be at Bigwin Inn, Lake of Bays, Ontario, Canada.

There is not a one of these divisions of heating, piping and air conditioning engineering that can not be said to be in the line of new technical developments. At each of these meetings there will be authoritative papers covering the new trends and practices which will contribute to better living and to more efficient manufacturing. Each, therefore, represents a valuable opportunity for the engineer to keep abreast of his profession.

There is "pay dirt" in engineering conventions. It is in the form of factual information that can be applied directly to engineering projects in which the conventionite is engaged.

Then, too, engineers are human beings, in spite of some belief to the contrary. They can relish and profit by contact with others in their line, if only for the good-fellowship.

So we say, leave the office, the plant or the shop and take in the conventions of the associations and societies which represent your interests. Sit in at the meetings, read the papers, take part in the discussions, talk to the other fellow and play some golf. It will all mean better engineering.

Lower Air Conditioning Cost

To the Editor:—

If engineering minds can find means for making possible air conditioning with a materially lessened initial investment and with a much lower operating cost, so as to make such equipments more generally applicable, they will have solved the greatest problem of air conditioning.

Many years ago the warming of occupied spaces in cold climates became first a luxury and then a necessity. Generally speaking, in but a limited number of new buildings is mechanical ventilation a necessity. Enlarging the term ventilation to air conditioning, and including cooling therein, we may say that air conditioning is today's luxury, but today's luxury is very often tomorrow's necessity. That which today is rare because of its initial and operating costs and is considered a luxury, may tomorrow be considered a necessity because of its very real contribution to comfort. Thus it is by no means beyond ready belief that the dawn of the application of air conditioning and cooling to residences and apartment buildings is about to appear, and that the time is close at hand when relief in the home in summer from excessive heat will be just as much in demand as is relief in winter from excessive cold.

(Signed) Dwight D. Kimball.

Refrigeration Limits

E. P. Heckel, past president of the Illinois chapter of the American Society of Heating and Ventilating Engineers, vice president of the Carrier Engineering Corp., and a contributing editor to this publication, frequently makes climatology and atmospheric conditions as interesting as the latest seller in literature.

A little group of engineers was gathered together in a downtown office one evening when the conversation drifted to the subject of cooling for comfort and the limits of refrigeration for hockey rink ice-making.

"You remember the incident in Madison Square Gardens," said Mr. Heckel. "It was the hottest November 19 experienced in New York in twenty-five years. A hockey game was scheduled between two crack teams. The ice, 20,000 square feet of it, from 5/8-inch to 3/4-inch thick, was made the night before, but on the day of the game the weather became quite warm—80 degrees in fact, outdoors. The refrigeration equipment was forced to its fullest capacity, but after the game was ended, there was about as much water as there was ice. The hot weather, 22,000 people, together with the concentrated heat from thirty-six 1,000 watt lamps located directly above the rink, was too great a handicap."

So you see there is a limit to the practical application of refrigeration in such cases. If the weather outside had been 60 degrees instead of 80 degrees, there would have been no difficulty in keeping the ice in condition. But ice is 32 degrees, and the difference between that and 80 degrees is 48 degrees. That is too much. If the outside weather were 60 degrees there would be a differential of only 28 degrees, which is about the limit. Of course, you could insulate the buildings and cool the inside to 60 degrees temperature under extreme outside conditions, but it would take an enormous amount of both refrigeration and insulation, far too much, in fact, to make it a practical proposition.

PRACTICAL PIPING PROBLEMS

Steam Mains—Installation and Maintenance
Location of Expansion Joints
The Thermostatic Trap

by
W. H. WILSON

Large Steam Mains

MANY industrial plants have large and long pipe lines, sizes 12-in. and over, used for the transmission of low pressure and exhaust steam. These large steam mains have certain characteristics which can give trouble to maintenance men unless properly designed, installed and maintained. For instance, there can be trouble from expansion unless correct piping practice is followed and certain methods of operation are pursued. And there can be trouble from faulty drainage of the water of condensation — trouble and expense.

The accompanying sketches illustrate the following description of the practice followed in a large industrial plant in installing and maintaining large steam mains. In this plant, low pressure steam (½ lb. to 3 lb.) is used for heating and process work, and the steam mains are in daily use, transmitting from a central point for a distance of one mile.

Unequal Expansion

It is not an unusual experience, unless care is taken to prevent it, for a large steam main, when steam is turned on slowly or moderately, to rise from its supports high enough to cause a strain that will break it in two. Such an experience comes to mind with some 14-in., 16-in., and 24-in. lines, with welded joints except at expansion joint connections. When turned on slowly, the steam would follow the top of the pipe for a distance of 200-ft. ahead of the bottom, heating the top and causing it to expand more than the bottom, which in turn caused the pipe to rise from the roller supports. This would take place between the expansion joints and, before the bottom of the pipe could become heated, the line, as mentioned, would rise from its support high enough to cause a strain that would break it in two. When the line was installed it was broken a number of times by turning the steam on in the regular way.

It was, therefore, necessary to turn the steam on as rapidly as possible and when this was done, the trouble was eliminated. This practice has been continued ever since, when turning steam on these welded pipe lines.

This trouble might have been avoided if more expansion joints had been installed in the line, but they were located according to standard practice and had ample travel on the sleeves to take care of the expansion. It is only the unequal expansion, when steam is first turned on, between the top and bottom of a large and continuous (by welding) pipe line that causes the trouble. The same trouble might be experienced with large steam mains having screwed joints, cast iron companion flanges, also. At times flanges are broken when turning on steam. This can nearly always be traced to the unequal expansion of the top and bottom of the pipe.

The industrial plant referred to above has its steam mains located in concrete tunnels and covered with a good grade of pipe covering. They are 12-in., 14-in., 16-in., 20-in., 24-in. and 30-in. in size. Some of these mains are of steel pipe, 5/16-in. thick, some of which have welded joints and others screwed flanged joints, cast iron standard companion flanges being used. Spiral riveted galvanized pipe, 14 gage for the 12-in., 14-in., and 16-in. sizes, 12 gage for the 20-in. and 24-in. sizes and 10 gage for the 30-in. size is used. All of this kind of pipe is flanged and as much as possible is in 20-ft. lengths. A.S.M.E. standard of flanged dimensions, as regards drilling and outside diameter, prevails.

With the proper knowledge of installing and maintaining these lines, they have been in constant use for a number of years, varying from 21 years for a 20-in. main, 600 ft. long, to 4 years for a 16-in. main, 1600 ft. long. As for the spiral galvanized pipe, made out of sheet steel, we know of a 30-in. steam line in constant use day and night, the year around, and a 20-in. steam line of intermittent use during the heating season only, both of this kind of pipe. These two lines were installed

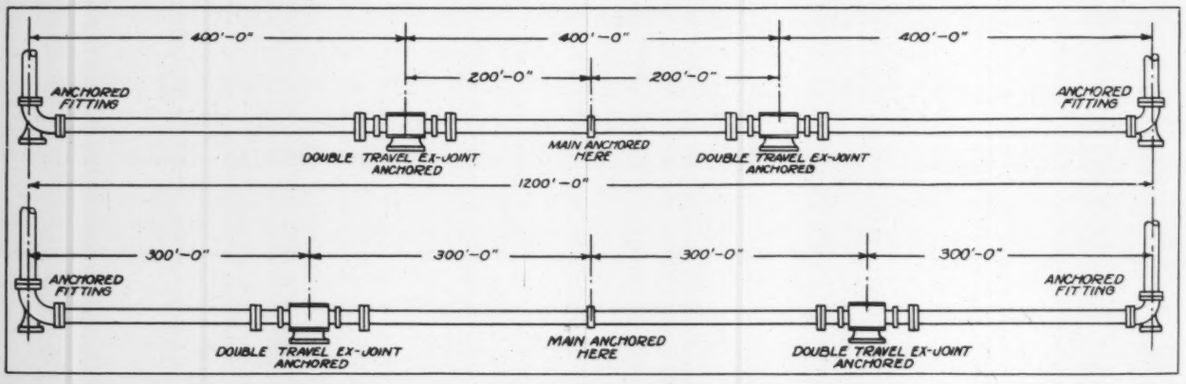


FIG. 1.—PROPER AND IMPROPER SPACING OF EXPANSION JOINTS

in 1910 and are in first class condition today. At all times when the interior of these steam mains have been inspected they have been clean and free from lubricating oil and sediment.

Large pipe lines, when installed in conduit or tunnels, usually have the pipe resting on roller supports. These supports should be placed approximately every ten feet, and arranged so that a support is near each joint, but not too close to a flanged joint so as to interfere with inserting and removing the flange bolts.

The roller supports should be accurately set in place so that the pipe will be kept in perfect alignment. This is sometimes done by supporting the pipe temporarily, getting it in proper place, and pouring the concrete piers for the roller supports so that they can easily be brought to the proper height to secure uniform alignment.

Location of Expansion Joints

The location of the expansion joints should be given careful consideration and arranged so that the travel will be evenly distributed on each sleeve. It is a simple matter to obtain tables of expansion of the pipe used for the steam line and by taking the difference between the lowest possible temperature that will affect the pipe line and the temperature of the highest steam pressure that will get into the pipe, the linear expansion can be easily computed, allowing some additional travel for a factor of safety as sometimes the best laid plans go astray. The temperature of the atmosphere at the time the pipe is installed must be given some consideration in determining the amount of expansion for which allowance must be made.

After deciding on the proper distance to set the sleeves of the expansion joint it is a good practice to place a block of wood to hold the sleeve in its proper position securely, but it must be distinctly understood that this wood block must be removed before the steam is turned on.

In case of single or double travel anchored joints, install the joint in its proper location, secure the pipe to the joint (by bolting the flanges if a flanged joint) and get everything in proper alignment. Then, anchor the joint last, by suitable anchorage, either by steel channels or anchor bolts set in concrete. Expansion joints should be securely anchored as pipe expanding has plenty of power to exert a strong push.

A good expansion joint will adapt itself to uneven alignment, but good workmanship requires that all piping be properly installed.

As to proper spacing the accompanying sketch, Fig. 1, shows improper and proper spacing in an actual case where the person laying out the pipe line could not be easily convinced that the expansion joints were not properly located, and it might be added that this person was "holding down" a job as construction engineer.

Proper Drainage of Condensation

Unless large steam mains are properly drained of the water of condensation, there will be costly maintenance labor and there will be a large amount of hot water thrown away. There are plants where maintenance men are constantly relieving the water by operating hand blowoffs and there are other plants where some, if not a great many, of the steam traps are leaking, or what is termed "blowing through." If many large plants were inspected closely and a fair and impartial report were made, these conditions would be found to exist, sometimes due to carelessness, sometimes to lack of proper supervision and sometimes to lack of interest and co-operation of the management in co-ordinating with the maintenance department and furnishing the equipment needed.

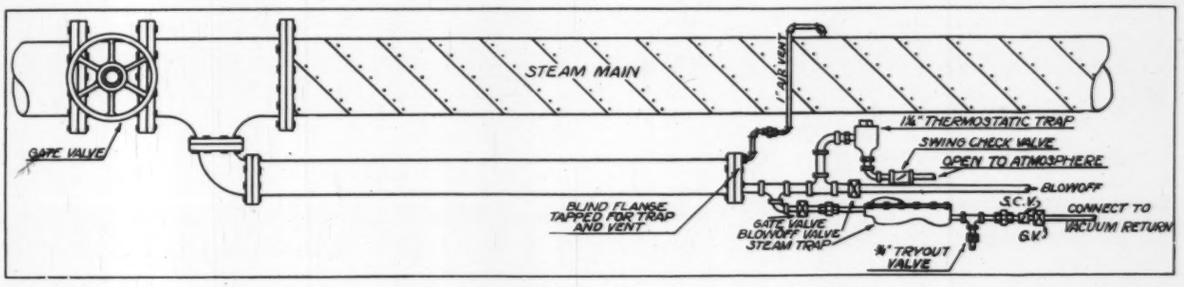


FIG. 2.—STEAM TRAP AND WATER POCKET AT END OF STEAM MAIN

Fig. 2 shows the installation of a steam trap and water pocket at the end of a steam main, arranged to provide proper drainage and to take care of a large amount of water that accumulates quickly when a long steam main is turned on. By this arrangement one man can conveniently put a long steam main in service without outside help.

The water pocket located under the main should be of a size depending on the length and size of the main steam line. Ordinarily a piece of 8-in. pipe, from 12 to 20 ft. long, will be sufficient to take the sudden rush of water that comes when turning on the main.

The 1-in. vent pipe is to allow the air to escape from the water pocket and the water to get into the pocket, thus permitting the trap to discharge water as soon as possible.

The trap has a tryout valve so that at any time it may be tested to determine whether it is "blowing through." This is done by closing the trap discharge valve, opening the try out valve and observing the trap discharging to the atmosphere. It might be mentioned that there is some steam vapor arising from a trap discharging hot water and allowance must be made for this before considering that the trap is passing steam. A swing check valve is placed on the trap discharge and the gate valve on the return side of the steam trap can be dispensed